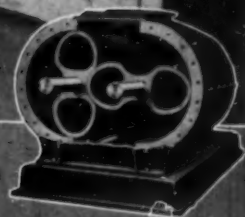
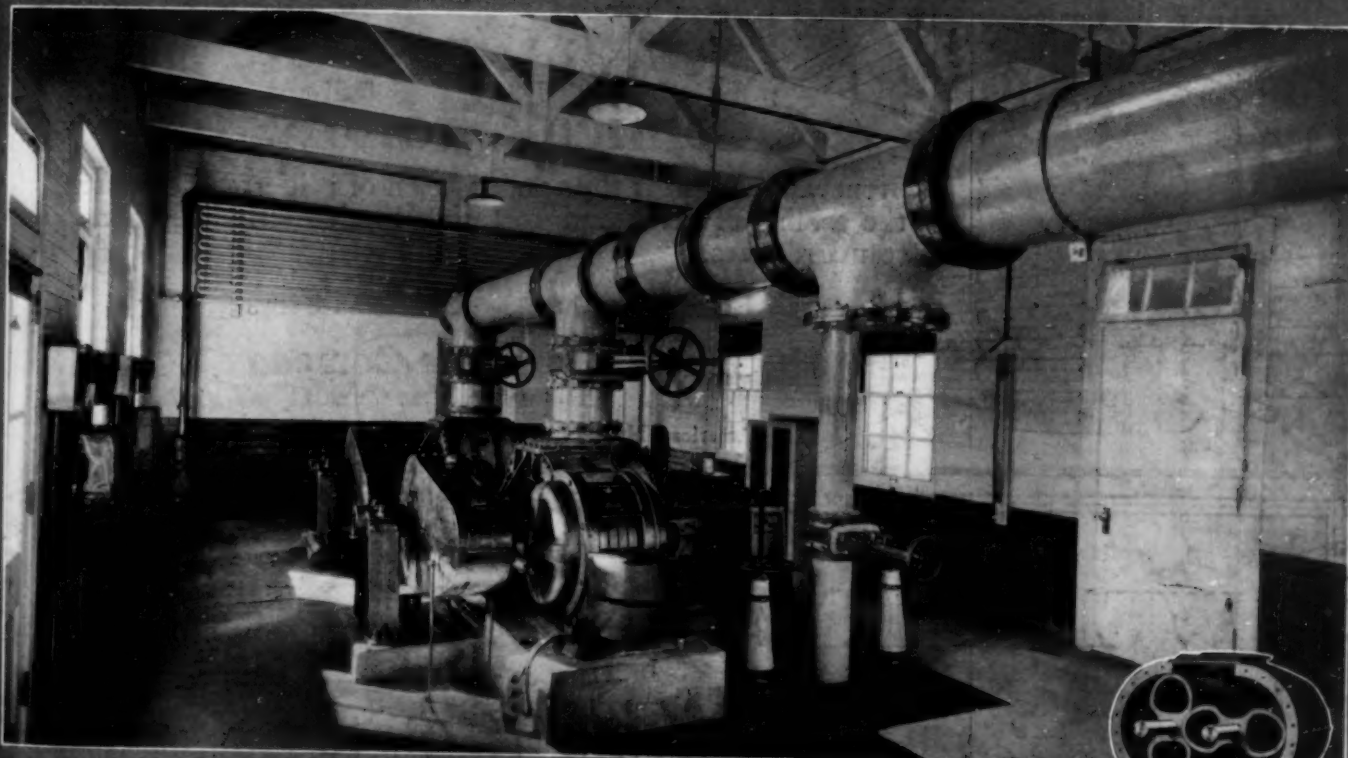


CHEMICAL & METALLURGICAL ENGINEERING

McGraw-Hill Co., Inc.

March 22, 1922

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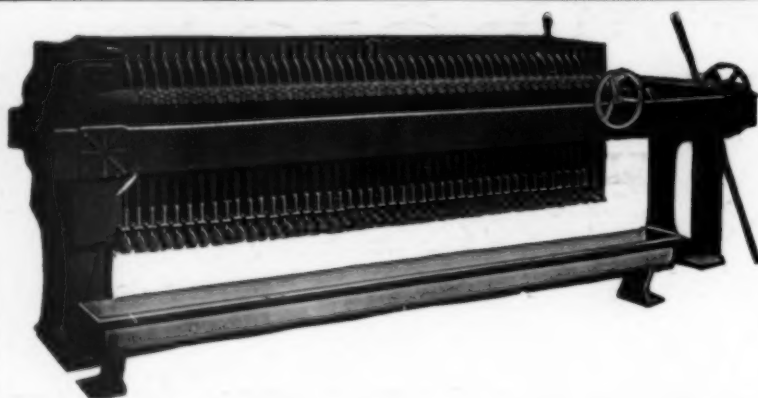
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A consolidation of
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Volume 26

New York, March 22, 1922

Number 12

The Explosibility Of Ammonium Nitrate

WHEN the nitrogen fixation works of the Badische Company at Oppau were destroyed by a tremendous explosion last September, the interest of American scientists and manufacturers of explosives was immediately aroused on account of the apparently mysterious cause of the disaster. It was known in a general way what was going on at Oppau—the fixation of atmospheric nitrogen by the Haber process and the manufacture of nitrogen fertilizers, among which was a combination of ammonium nitrate and ammonium sulphate—and yet no valid reason could be assigned for the explosion. Although it was ascertained subsequently that the explosive decomposition of 4,500 tons of sulphonitrate of ammonia was responsible for the disaster, the cause is still unexplained. Investigations begun abroad and in this country are still in process from which it is hoped information will be derived not only to serve as an explanation of what happened at Oppau but to guide us in our own development and use of synthetic nitrogen fertilizers. The investigations are of particular importance in view of the rapidly expanding use of ammonium nitrate.

In our attempts to throw as much light as possible on the explosion we gathered material from various sources, and in an editorial comment on November 2, 1921, we made the following statement:

Furthermore we are confronted with the fact that ammonium nitrate itself is something of a mystery. Those who know anything about powder plants cannot help recalling instances when it acted as it shouldn't. We are told that once upon a time, of twenty vessels working up ammonium nitrate, No. 6 and No. 18 suddenly exploded, demolishing several others. At the same instant some barrels of nitrate in a storage shed went off and only scattered holes in the ground were left to mark the places where they stood. Surrounding barrels were broken and charred, but did not explode.

The purport of our comment was to convey an idea that we found prevalent—namely, that there was a general lack of precise knowledge of the properties of ammonium nitrate and that consequently it was "something of a mystery" with regard to its explosibility. It appears, however, that our opinion was interpreted as meaning that one could not tell under what conditions ammonium nitrate might explode and that, therefore, there were some inherent and unknown dangers in its manufacture, transportation, handling and storage. This, of course, was a misinterpretation of our thought, because as far as we were then or are now aware, ammonium nitrate is explosive only under exceptional conditions of high pressure and powerful detonation. Our comment was, however, open to this criticism: That due to lack of complete information we made it appear that the two explosions mentioned were almost simultaneous, one dependent on the other, whereas they were widely separated, not only as to time but also as to locality.

What are the facts as to the explosibility of ammonium nitrate? Considering the apparent lack of precise knowledge of its properties and behavior, it seemed advisable, in the interest of scientific accuracy as well as industrial progress, to obtain from an authoritative source an article embodying our present knowledge of the material and of explosions in which it has played a part. Such an article is published in this issue from the pen of Dr. CHARLES E. MUNROE, Chairman of the Committee on Explosives Investigations, National Research Council. The merit of Dr. MUNROE's article will be apparent to all who read it, but we may indicate some of its points of excellence. In the first place, it is a complete compilation of the known properties and behavior of ammonium nitrate; second, it embodies the only authoritative statements that have ever been published regarding four important disasters in which ammonium nitrate played a part; and third, it gives the results of tests on the explosibility of ammonium nitrate made in this country after the Oppau disaster. It will thus be seen that the article is an important contribution to our knowledge of the subject, and we believe there can be no dissension from the conclusions of the author, that while ammonium nitrate offers a fire hazard, it cannot be regarded as an explosive *per se* under ordinary conditions of transportation and storage.

Effectively Crippling Chemical Warfare Service

THE appropriation of half a million dollars for the next fiscal year's work of the Chemical Warfare Service was well characterized by one prominent government official as "absurdly small." This sum is wholly inadequate to the responsibility which is placed upon this branch of the Army, and it is to be hoped that the House of Representatives or the Senate will find occasion to increase this sum, which has just been recommended by the House Committee on Appropriations.

The report of this committee includes the following comment:

The budget estimate for Chemical Warfare Service was \$1,500,000, which was later reduced to \$500,000 in view of present conditions. The latter amount is recommended by the committee to provide for a minimum amount of development work and training along lines compatible with present conditions, and maintaining Edgewood Arsenal in stand-by condition.

Behind this statement there is a bit of interesting history. The budget estimate was for continuance of C.W.S. on the same basis as recommended a year ago, but during the hearings on the bill certain officials in the War Department and the Army appeared before the Congressional sub-committee which was holding hearings and changed the basis of the recommendation. It is understood that they not only reduced to one-third the appropriation originally requested but also urged that C.W.S. be abolished and that the smaller sum recom-

mended be granted to the Ordnance Department, which, in their judgment, should do the work now under C.W.S.

In the course of writing the treaties at the Conference for the Limitation of Armaments, it became evident that the Chemical Warfare Service had influential enemies in high position; recent developments emphasize this fact. These officials apparently have succeeded now in making a move for crippling the Service.

The chemical industries of the country have come to look upon the Chemical Warfare Service as one of the links in our chain of industrial chemical activities. Our industries cannot view without apprehension any curtailment of the fundamental research and development activities of C.W.S. Chemists know too well from experience that the development of chemical agencies of attack or defense is not the work of days or weeks, but rather of months and years. They know how foolhardy it is for our nation to remain unprepared in matters such as this. They know that only chemists working under sympathetic supervision of other chemists can maintain the intimate acquaintance with chemical industry upon which chemical warfare of the future will so much depend if the occasion ever should arise for this type of military activity.

The officers of the Chemical Warfare Service are keenly alive to the seriousness of the situation. They are doing everything in their power to present fully to our legislators the pertinent facts. But they need and well deserve the co-operation of chemists and chemical industry generally. These latter must make it known that they do not regard as a safe procedure the curtailment of chemical warfare studies in any such ruthless manner as this. Moreover, they should make it evident to Congress that such curtailment is false economy, for through no other arm of the service can the defense of the country be so cheaply and effectively planned. Studies for defense are not prohibited by the letter or spirit of the pending treaty.

"Not Much Hope For Better Cement"

THIS is the heading under which one of the leading engineering and construction journals of the country recently presented a portion of its editorial review on concrete and cement. It is unfortunate that engineers who use most of the cement in the United States should be given this impression. Certainly the chemical industries in general, and the cement industry in particular, are not prepared to admit that there is no further opportunity for improvement of portland cement.

The review in question acknowledged that practically all commercial supplies of cement pass the present standard specifications and that proper use would almost invariably insure a certain strength of construction. However satisfactory this condition may be in general, it is not a welcome thing to have the added thought expressed "that the cement makers themselves are satisfied with the present situation, and that they are more anxious to preserve the present standard specification than to get a better product." It may be that a few in the business would be willing to take such a stand privately, but it is certain that there are in the portland cement industry of today those who are not content to permit this product, good as it is, to remain indefinitely of only the present standard of value.

Standard specifications of the sort which are now widely used for cement are certainly much more satisfactory than the many diverse specifications which were

common 10 or 20 years ago. But present standards must not become a deadening influence on the industry. Progress must be maintained. And progress means continued increase in the rigidity of the specifications.

Any industry which would accept without challenge such a charge as has been made against cement would soon find itself supplanted by newcomers in the business or by other branches of industry which would furnish substitute products. Research is essential to progress in any business, and research must and will continue regarding materials, methods and marketing of portland cement. It is to be hoped that this criticism, which we believe is unjust, may prove an added stimulus to the industry for greater advancement.

A Suggestion for Fixing Wage Scales

ON MARCH 4 the Chemists' Club of New York had one of its several Saturday luncheons with speakers who are guaranteed not to be chemists. On this occasion IVY LEE, adviser to the Association of Railway Presidents in matters of publicity, spoke on "The Railroad Situation," and HUGH FRAYNE, organizer for the American Federation of Labor, on "What Labor Wants."

Both talked about wages, and they were in entire accord about the Railway Labor Board. Both agreed that the very presence of such a tribunal invited dispute, and that before a tribunal each side is likely to present maximum claims as minima—in other words, to bid high for itself. They were in agreement also that the best settlers of problems at issue are the interested parties themselves.

We have not space to review the many other features of the railroad situation brought out by Mr. LEE, or to record their sometimes sympathetic and sometimes opposing views in regard to the problems of labor. But to an attentive listener it seemed that both were talking around the fringes of applied psychology.

There is the unsolved problem of the feeble-minded in the ranks of labor. That was not discussed. It stands to reason, however, that they naturally gravitate to those occupations that do not call for mentality in work and that, like children, these defectives keep organized labor "in wrong" by their frequent breaches of agreement and their resorts to violence.

We believe, however, that the opportunity offers itself for a step in advance in the interest of both employers and organized labor, although it would have to be tried out in some establishment in which the employer and his organized workmen are on terms of cordial amity. There must be confidence on all sides for the experiment to be tried. Then the employer can say to the representatives of his men:

"We have a payroll of n dollars a week, and what I propose will not change that. And I do not propose any changes in the hours of labor. But in fixing rates of pay and in all our agreements, we have both been guessing. We have guessed and compromised to reach our present scale. We do not really know the comparative value of the service done in the various jobs in these works. Applied psychology can integrate these various parts of the work and fix comparative values. I propose to get from President ANGELL of Yale or President HAMERSCHLAG of Carnegie Tech of Pittsburgh, or from somebody else, a couple of good, experienced psychologists to come here and make a study of a comparative wage scale for our work. They won't

know anything until they have been here for several months. After they have made their study, however, they are to make their report and then let us take it up together. We shall not propose to cut wages for any job below an agreed minimum, but I want to know which positions carry the responsibility and to put a premium on these. I want also to know which positions do not call for thinking, and to keep them for our men who can't remember or can't see ahead. I shall not attempt to put through any new schedule until we have agreed on it, and I want you men to make this study with me."

By this means he would provide better pay for his more competent and ambitious men. He would take care of the incompetents who now drag the others down. He would establish an *esprit de corps* that would otherwise be unavailable. And he would do more for organized labor if he were to work this problem out with his men than forty new laws and a hundred strikes.

A Short Road To Fame

THERE was a time when it seemed to us that the peak of fame was attained when a locomotive with red wheels and brass trimmings was named for a man. With increasing stature our taste in fame changed, and we thought if our name were used for a good, free-smoking 5 cent cigar, for the purpose of drawing custom to it, that would represent popularity if not fame. Now with the mask of age grinning in the western offing our ambitions have become less definite.

But here is a new opportunity to make a name known. The chemical laboratories of the leading Polish universities and polytechnic institutes are without equipment. Every bit of platinum and all apparatus and reagents have been taken away by the armies that passed through. The students are there, and so are the professors, but they can't demonstrate, and they can't buy anything with Polish marks, and Polish marks are all they have. These are the universities of Lwow (Lemberg), Warsaw, Cracow, Posen and Wilno, and the Polytechnic Institutes at Lwow and Warsaw. At the current rate of exchange all their chemical laboratories could be generally equipped for about ten thousand dollars. The country is very democratic; they haven't any Order of the Green Eagle of the Sixth Class or Knighthood of the Royal Shoe Lace or other decorations to bestow. But they would put up a tablet in each laboratory, worded in Polish somewhat to this effect: "This laboratory was equipped after the devastation of war through the generosity of JOHN JONES, president of the Jones Company, Jonesville, Ohio, U.S.A." Then generations of educated Poles would honor and respect his name in enduring gratitude. It would be known throughout Poland. There would be Jones legends and Jones myths, all told with a whizzing and skyrocketing accompaniment of consonants in the Polish language. They would burn candles in memory of him when he died, and call their babies after him. He would stride down the aisle of Fame as the Benefactor of Science in Poland.

Any sum may be sent to HUGH GIBSON, U. S. Minister to Poland in Warsaw, for the purpose named, to be distributed through the Mianowski Foundation, of which the director is Dr. S. MICHALSKI, Vice-Minister of Education, and the Council is made up of representatives of the different universities.

How Did the 1919-20 Boom Happen?

WHEN business began tapering off in the latter part of 1920 the talk immediately arose that there was "a strike of buyers" and when business began to appear really stagnant a common remark was that resumption of activity merely awaited the quoting of lower prices—that men knew just what they were waiting for. Apparently we had the situation "doped out" pretty well.

More recently, however, there is a new view. There is not going to be a return to 1919-20 conditions, minus fancy prices. It is proved to be impossible to do that. We cannot have a much higher scale of living than we had before the war, and we may not be able to have even as good a scale, until we have made up for the waste of war. We shall have to work harder and more efficiently in order to get along at all.

The new teaching is very logical and appealing. It appears to hang together very nicely and to be in harmony with all the known facts, with one exception. The exception is that if these things are impossible, a better scale of living, more income with less work and all that sort of thing, how is it that it did happen in 1919 and 1920?

A partial but more than a 50 per cent answer is that it didn't. We did not have nearly as great industrial activity in 1919 and 1920 as we thought we had. We took our cue altogether too much from prices, judging that because a material was high priced it was in very heavy demand and that demand was outrunning supply. In many cases the supply was not large, and part of it was held back by speculators. Then, furthermore, we judged the physical volume of trade too much by the money standard. Reduced to physical units the quantity of business was not so large. Applying to the record of money turnover, as shown by debits to individual accounts at banks, a correction on account of prices and **inflated values**, it appears as if the physical volume of business was less in 1920 than in 1919 and that in 1921 it was larger than in 1920.

The explanation of the 1919-20 industrial activity—that it didn't occur—is incomplete. All the rest of the answer may not be available at the moment, but some further explanation of the phenomenon can be found. We had what appeared to be an active and profitable export trade, but the records show that a large part of the exported merchandise has not been paid for. According to the Federal Reserve Board's investigation, about three billion dollars of unfunded balance due to the United States accumulated during 1919 and 1920. We did not know at the time that we were not going to be paid with reasonable promptness, and in respect of this amount we were less prosperous than our imagination led us to believe.

Then we had some fictitious prosperity through the spending of what were considered profits made during the war, both before and after the United States entered. In numerous cases high prices were paid for commodities, the extra price being paid to reimburse the producer for the cost of additional plant facilities which would be more or less valueless after the war, but the recipients called the money real profits and did not apply it to writing down the property account.

In time it will no doubt be possible to explain away the apparent boom in 1919 and 1920, but we know enough already to be willing to admit that positively we cannot, in consequence of a great war, consume more in proportion to what we produce than we used to do.

Readers' Views and Comments

When Does an Employment Contract Terminate?

To the Editor of Chemical & Metallurgical Engineering

SIR:—Having read the editorial in your issue of Feb. 22, page 338, and the comments of Wellington Gustin, page 341, I would like to point out to you that there is considerably more in this question than is indicated either in the editorial or in the communication referred to.

In the first place, if you will refer to "American and English Decisions in Equity," vol. 9, you will find that the appellate courts have decided such subjects as "Property Rights in Trade Secrets," "Who May Be Enjoined From Using or Disclosing Trade Secrets," "Contracts Not to Use or Communicate Trade Secrets," "Implied Contract Not to Divulge Trade Secrets," "Use of Knowledge Acquired During Employment" and the "Status of an Employee Who Discovers Secrets," together with many other decisions which more or less form complete information on the subject referred to.

I have in mind two cases which I arbitrated which come under this particular heading.

A certain firm engaged a chemist to make for it a number of improvements in one of its processes. This the chemist did and during the course of his work he made some important discoveries, which he patented. Before going to law in the first case, both the chemist and the employer decided to permit me to arbitrate the case, and I decided in favor of the chemist on the ground that he rendered useful service for the wages he received and that he was entitled to extra recompense for the intellectual property which he possessed, and the case was very satisfactorily settled, the chemist turning over the patents for what I considered a reasonable sum.

In another instance an improvement was made in a piece of apparatus which rightfully belonged to a chemist who had worked it out during his employment, and I again decided in favor of the chemist on the ground that he had given full value for the wages he obtained in the first place, and in the second place there was no contract between employer and employee which implied that the chemist was to turn over without consideration any invention that he should make. On the other hand, there is a well-known implication of law which works the other way, that no chemist after he leaves the corporation can make use of a process which he has learned during the time that he is employed. The rule in equity which is followed in this case is that when you engage a butler you do not tell him that he must not steal your silver, for such a condition is implied, so that anyone leaving a corporation's employ and taking with him intellectual property which he has acquired without any efforts of his own is clearly not entitled to use such information for his own benefit.

The whole question may be summed up into this, that chemists and other intelligent employees are engaged verbally or by written contract, and the question of intellectual property is seldom entered into. If a man obtains a position and gets a fair salary and makes a contract in writing that he will turn over all his discoveries in consideration for the salary he obtains, the decision in a case of that kind must be very obvious,

but where nothing is stated, and where both parties are fair, it is very simple to arrive at a just conclusion, as in the two cases which came before my notice.

I have always contended that every professional man ought to listen to a six months' course of lectures on contracts during or directly after his college course.
New York City.

MAXIMILIAN TOCH.

To the Editor of Chemical & Metallurgical Engineering

SIR:—I wish to write you regarding your editorial on "When Does an Employment Contract Terminate?" in the issue of Feb. 22 and the interesting comment on it made by your Chicago correspondent in the same issue.

This writing of proper contracts is difficult. If in error, they have been generally unfair to the technical employee rather than to the corporation. About the only constructive criticism I have heard, other than that given by your Chicago correspondent, has been that the American Chemical Society or perhaps the more progressive and smaller organization, the American Institute of Chemical Engineers, should employ an attorney to get out forms of standardized contracts and also should arrange for this attorney to advise any chemist or chemical engineer as to proper types of contracts or as to the true meaning of contracts which are offered him by a corporation. It seems to me that it ought to be possible without great difficulty to get typical standardized contract forms which would be fair to both the technical man and the employer.

RALPH H. MCKEE.

Department of Chemical Engineering,
Columbia University,
New York City.

To the Editor of Chemical & Metallurgical Engineering

SIR:—I read with considerable interest your editorial and comment regarding the relation of a chemist to his former employer.

When a man is doing research work, this research work is rather specific. He is either working on a particular compound or group of compounds, or on a particular reaction. The chemist brings to this work certain training and experience. The employer brings, we will say, certain private plant information and commercial knowledge. They work together on some agreed-on basis, and the results of the work, whatever they are, belong to the employer. Suppose the chemist quits or loses his job. What is his status? He has the same training and equipment as he had before he started on this particular piece of work, and he has in addition the advantage of experience in doing the work. The employer has taken nothing from him but the results of a particular piece of work, and presumably it was agreed in advance, for a definite remuneration, that these results should belong to the employer. The chemist is now free to find another job, and as far as I can see the whole field of chemistry is open to him without question, excepting the specific reaction or the specific compound or group of compounds on which he worked for this employer.

In long experience as a consultant with many employers I have never had a difference of opinion with any of them as to what lines it would be proper for me

to follow and what lines I should not follow in view of the work I had done for them and the private information they had necessarily given me. In dealing with chemists who work for me or under me, I have never had a difference of opinion either. In this latter case I ordinarily ask the men to refrain for 3 years from working on the particular problem on which they were doing research work for me. This is no limit of any consequence to the usefulness of the chemist or the broadness of his field of work, and sufficiently protects the employer. If there is a clear understanding at the outset of the work as to what the arrangement is under which the work is being done, and any tendency to be fair on both sides, no real question of conduct will arise at all.

JOHN E. TEEPLE.

New York City.

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read both articles in *CHEMICAL & METALLURGICAL ENGINEERING* on "When Does an Employment Contract Terminate?" and I feel that there is a certain injustice in the rigid conditions that are often incorporated in the employment contracts of chemists and chemical engineers, but there are two sides to this question.

With a chemist who has actually brought something to his employer which is his own work and his own idea, the chances that his services will be dispensed with are very slight. Even under present heart-breaking conditions when it is imperative to reduce expenses to a minimum to safeguard the future of many establishments, he is likely to be retained. Such men in addition to a salary are as a rule given a share of the profits or savings of their invention and these payments continue for stipulated periods if for one reason or another they sever their connections with the firm.

If, on the other hand, a young man is taken into a laboratory or works where secret processes are in operation, with the development of which he has had nothing to do but with which he is made familiar in order to supervise their working, I think it is perfectly fair that he should be restrained from using such knowledge for his own benefit or that of others. Often such processes are based on the preliminary work on other products produced by his employer and are the result of years of untiring labor and the expenditure of vast sums.

In such cases a contract prohibiting him from engaging in work of a similar nature for a period of years is perfectly fair and equitable.

F. G. ZINNSER.

Hastings-on-Hudson, N. Y.

The Needy Russian Scientists and Men of Letters

To the Editor of Chemical & Metallurgical Engineering

SIR:—In several of your editorials you have called attention to the suffering Russian scientists, suggesting that something be done to relieve their sad condition. I do not know whether there were any responses to your call, but if there were not it may not be for lack of sympathy or desire to help the starving Russian scientists, but rather on account of the uncertainty whether the help would reach them.

In view of the above I wish to call attention to the possibility of sending food products now through the American Relief Administration (Hoover's organization). This organization accepts money in units of \$10 and through its agents in Russia delivers an equivalent in food products to the persons designated. Food can be sent to individuals or to the Mutual Aid Society of

Scientists and Men of Letters. The address is as follows: House of Science, Basseynaya 11, Petrograd, Russia. Individuals can be reached at the same address.

Food remittance blanks can be obtained in most of the banks or directly from the American Relief Administration, Russian Food Remittance Department, 42 Broadway, New York City.

IVAN M. BREGOWSKY.

Chicago, Ill.

The Manhood of Humanity

To the Editor of Chemical & Metallurgical Engineering

SIR:—I rather feared that somebody would take exception to my praise of Korzybski's book called "The Manhood of Humanity, or Human Engineering." It has been the subject of considerable disagreement between just such competent and level-headed persons as Mr. McDonald and Prof. Cassius J. Keyser. Then there are the rest of us who, without distinction as to our merits as thoughtful readers, seem to take sides about it.

I think all will admit that human society is in a bad way. There is a distressing lack of ideals in the public mind. The supreme need that we fulfill our obligations is not well developed in these days. I believe it will be generally agreed that society needs quickening in the consciousness of its obligations more than in any other respect.

To some of us this idea of time-binding, this requirement that we add our contribution to the work of the dead and pass it on to coming generations as the only way to maintain humanity in a state of progress, seems important. Time-binding does not present the requirement as a virtue, but rather as a necessity. It shows that if we destroy the work of the dead we rob future generations, and we become ghouls, as Count Korzybski puts it, who live on the dead. The distinction between what is good for humanity and what is bad for it is older than history. The book, to some of us, makes this distinction, which has grown rather cloudy under the blinding rages of war, clear and living again. This is important, even if only a few gather such light from it.

New York City.

ELLWOOD HENDRICK.

The Electric Melting Furnace

To The Editor of Chemical & Metallurgical Engineering

SIR:—A scientific innovation is doomed to pass through a definite cycle of ups and downs before it finally comes to rest on a firm foundation of real and rational utility. Brought to light to a circle of the favored few, it is for a time an object of wonder, almost of veneration. Then follows the period of ridicule. The public seizes upon it as a curiosity, a dream creation, a plaything for highbrows. But practical? No!

Then some firm of established reputation adopts the new thing after careful and laborious investigation. A whirlwind of popularity ensues. The new invention immediately becomes a panacea for all evils. Wild advertising makes it a household word. It is invested with miraculous virtues it does not possess. It becomes the popular savior of a troubled technical world. Everyone who can possibly find or imagine a use for it quickly adds his name to the list of anxious purchasers.

Then the bubble bursts! It is found that brains and experience are adjuncts to success. The thing that required only cheap unskilled labor—according to the advertisements—is found to be as stubborn as a balky mule, and failure after failure is registered.

Finally popularity wanes, and the new invention finds its way to the hands of the few who know its uses, its

limitations and its difficulties. It has found its niche in the scheme of industry.

At the present time, the electric furnace is riding the crest of the wave. Tales of the electric furnace find their way into the transactions of our technical societies. Journals carry highly colored advertising. Purchasing agents will pay premiums for "electric steel."

The electric furnace is an ideal method for certain types of melting. Oxidation is almost negligible. Accuracy in composition can be obtained with reasonable certainty. The electric furnace is an admirable super-heater. Heats can be held with safety at almost any range required. The electric furnace may be depended upon not to burn up good material that may be put into it. But while it proves to be a first-class nurse for healthy material, it is a poor doctor for sick material.

If we cut through the mass of variations heaped upon the principle of electric melting, what is left? If we disregard phase, single and multiple arcs, direct and indirect, electrodes top or side, vertical or inclined, what does the electric furnace become? Simply a crucible heated internally instead of externally. A crucible independent of impure fuel, and independent of careless firemen.

Every steel man knows that he cannot make good steel from poor materials in an externally heated crucible. Then by the simple expedient of changing the fuel, how does he expect to perform that miracle in an electric crucible? Yet that is just what many persons expect to accomplish. What wonderful cleansing power can there be in electric heat? The argument has been advanced that the atmosphere of an electric furnace is neutral, therefore no oxidation can take place. I admit that the electric furnace establishes a kind of quarantine against the atmosphere. A quarantine will probably protect against the entrance of outside poisons, but can a quarantine cure the effect of poisons already within?

In other words, can the electric furnace hope to reduce metal that is oxidized before it goes into the furnace? Will electric heat reduce rust? This is almost an impossibility in any other kind of furnace. We know that rusty, dirty scrap is the cause of endless trouble in the open hearth. I should like to see a heat of high-grade cast iron made in an electric furnace from a charge of burned grates. It has been contended that the electric furnace, because of a neutral atmosphere, permits heat to be held for a long time, when dirty baths can be cleaned by gravity. It may be possible to raise a goodly portion of contained fusible slag, but will infusible finely divided sonims rise? Will absorbed gases free themselves? Passing from theory to practice, why are foundries melting with electricity so liberal with aluminum when casting their metal? And why are so many porous castings poured from electric steel?

It is not my intention to ridicule the electric furnace. It is a valuable piece of equipment. But it is essentially a crucible and nothing else. If we restrict the use of the electric furnace to the production of alloys—its original field, where heat is the main essential—and to material of crucible quality—simple, safe melting of first-class materials—and if we take advantage of the ability of the electric furnace to produce crucible quality in quantity, then we shall have found the niche for this invention.

HENRY TRAPHAGEN.

Toledo, Ohio.

EDITOR'S NOTE.—Mr. Traphagen's letter is interesting as a protest against blatant exploitation of mediocre or even inferior material, simply because it has come

from an electric furnace. He is doubtless correct in his inferred complaint that the electric furnace, *as ordinarily run*, will not reduce oxide; with no particular effort made to seal all openings, the furnace atmosphere is often powerfully oxidizing. Nor is there any wonderful cleansing power in electric heat.

However, the electric furnace has one distinct advantage which the crucible has not, and that is that the skilled metallurgist can make up various slags on his metal, and thereby submit the molten bath to a sequence of chemical reactions (aided by mechanical stirring) which are impossible in the crucible. This is unquestionably the reason why good open-hearth steel can be bettered in an electric furnace, *properly operated*.

Lacking a precise and convenient analysis for gases in metal and in view of our considerable ignorance on the constitution of slag inclusions, we can only infer the actual effect of oxide on steel. It is in consonance with the principles of physical chemistry to suppose that a steel refined under a calcium carbide slag free from metallic oxides, will itself be practically cleansed of oxide inclusions. We do know that when such steel, made of reasonably good material, is properly cast and forged it exhibits unexceptionable tensile properties and beautiful silky fractures, with little or no evidence of transverse brittleness. Few open-hearth steels can even approach this.

Sulphuric-Acid Air Lift

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with interest the letter of Mr. Imison regarding the Bihn-Jones automatic device for elevating sulphuric acid by compressed air, referred to in the article by Mr. Fairlie on the sulphuric-acid industry.

This device is for all practical purposes identical with the Plath Automatic Acid Elevator that has been manufactured in chemical stoneware by the General Ceramics Co. since 1907 for moving any kind of corrosive liquid. It was fully described in a paper presented by Dr. G. Plath before the Verein deutscher Chemiker on April 16, 1902. It was at that time manufactured by the Deutsche Ton & Steinzeugwerke of Berlin and had then to my knowledge already been on the market for some considerable time.

This would indicate that the idea originated with Dr. Plath and was possibly adopted by Mr. Barnes to construction in metal. Whether this is the case or not, it is quite certain, as Mr. Imison implies, that the credit is not due to Bihn-Jones.

PERCY C. KINGSBURY.

New York, N. Y.

Greensand as a Source of Fertilizer Potash

To the Editor of Chemical & Metallurgical Engineering

SIR:—In "Greensand as a Source of Fertilizer Potash," published on page 1056, vol. 25, the weight of mother liquor, caustic soda (37.5 deg. Bé.) was given as 90 grams. This should read 900 grams.

New York City.

R. NORRIS SHREVE.

Study of Gas From Destructive Distillation of a Mixture of Water-Gas Tar and Coal

To the Editor of Chemical & Metallurgical Engineering

SIR:—The heading of the fourth column of Table III in my article, published in the issue of Feb. 22, should read "Theoretical Alcohol Equivalents in Grams" instead of "Hydrocarbons in Grams."

Pittsburgh, Pa.

RALPH L. BROWN.

The Explosibility of Ammonium Nitrate

A Review of Its Known Properties and Behavior and a Study of Accidents in Which It Was Involved—
These and the Results of Recent Scientific Tests Form the Basis of Important Conclusions
Regarding Transportation, Storage and Use of Ammonium Nitrate

By CHARLES E. MUNROE

Chairman, Committee on the Investigation of the Explosibility
of Ammonium Compounds, National Research Council

THE very severe and most disastrous explosion which occurred on Sept. 21, 1921, in the nitrogen fixation factory at Oppau, where ammonium nitrate was being produced on a large scale, has led to the publication of many articles indicating a lack of precise knowledge of the properties of this compound. Notwithstanding the many records in the literature and the relatively recent and definite statement of the Bureau of Mines,¹ these articles often manifest a rather general feeling of surprise at the fact that ammonium nitrate is, under certain circumstances, explosive *per se*. In view of the long-continued use of ammonium nitrate and its very rapidly growing importance in our industries, and in view, further, of the fact that a lack of precise knowledge of the properties and behavior of this substance may lead to unnecessary and burdensome restrictions being placed upon its manufacture, transportation, storage and use, it seems advisable to review the case for ammonium nitrate and, in doing so, to present the results of recent tests that have been placed at my disposal.

USES OF AMMONIUM NITRATE

For Producing Nitrous Oxide: With the identification of nitrous oxide (laughing gas) by Priestley in 1776, the discovery of its physiological effects by Davy in 1800 and its application as an anæsthetic by the American dentist Dr. H. Wells in 1844, this substance, produced by the thermolysis of ammonium nitrate, came into a continually extended use in dentistry and in more recent years as a component of anæsthetics for other purposes. Statistics of ammonium nitrate for this use are difficult to obtain, since, though from the standpoint of use this is a very important industry, from the standpoint of monetary value it is a very minor one. The U. S. Census of 1905² reported a consumption of 75,894 lb. of ammonium nitrate for the production of nitrous oxide. From the circumstances of the case it is believed that this figure was too low and there is little doubt that at the present time the amount so consumed is many times this.

In Explosives: It is obvious that ammonium nitrate, like saltpeter and other nitrates, readily and easily forms explosive mixtures with combustible substances. Many such mixtures have been proposed and a considerable number used. As early as May 31, 1867 (the same year in which Nobel obtained his English patent for dynamite), a Swedish patent was issued to Ohlson and Norrbin for an explosive composed of a mixture of ammonium nitrate, nitroglycerine and carbon. The hygroscopicity of ammonium nitrate was an obstacle

to the use of such compositions, but when, on Feb. 10, 1885, U. S. Patent 312,010 was issued to R. S. Penniman for "Protected Nitrate of Ammonia for Use in Explosive Compounds," a new impetus was given to the use of this salt, for, by coating the grains of the ammonium nitrate with petrolatum, Penniman waterproofed them sufficiently for economic use. Partly because of this and partly from other causes the use of ammonium nitrate in explosive compositions, and especially the so-called "safety explosives," has steadily increased, so that, according to Howell,³ 90 per cent of all "permissible explosives" sold in the United States in 1920 belonged to the ammonium nitrate class and that the total quantity of ammonium nitrate in them aggregated 31,831,000 lb. It is probable that the quantity of ammonium nitrate used in the 229,112,084 lb. of high explosives other than "permissibles" sold in this country in 1920 greatly exceeded this amount.

During the late war ammonium nitrate found wide acceptance as a component of the amatols, ammonals, sabulites and many other explosive compositions that were extensively used in military operations. Considering all the circumstances, Crowell's statement⁴ that before the Great War 58,000,000 lb. of ammonium nitrate was used annually in the manufacture of commercial explosives in this country and that our total capacity for the production of this salt at the time of the signing of the armistice was 20,000,000 lb. per month is well within the mark.

Ammonium nitrate in the explosives industry affords a convenient and economic means of utilizing the weak nitric acid recovered from the spent acids of this industry.

As a Fertilizer: Ammonium nitrate contains upward of 35 per cent of fixed nitrogen available as plant food. One half of this nitrogen is present in the nitric form, and the other half in the amino form. Compared with other substances used as fertilizers ammonium nitrate is found to contain more than twice the nitrogen content of sodium nitrate, nearly 14 per cent more nitrogen than ammonium sulphate, practically the same nitrogen content as calcium cyanamide and but about 12 per cent less nitrogen than urea, this comparison being based upon the assumption that each of the compounds named is pure and in the anhydrous condition. Ammonium nitrate possesses the advantage over ammonium sulphate, calcium cyanamide and urea in that, while the entire nitrogen content of each of these three bodies is in the amino condition, one-half of that of ammonium nitrate is in the nitric condition, and over sodium nitrate in that, while containing about 1 per cent more of

¹"The Analysis of Permissible Explosives," C. G. Storm, Bull. 96, Bureau of Mines, Washington, (1916), p. 7-8.

²"Chemicals and Allied Products," Charles E. Munroe, Bull. 92, Census of Manufactures, 1905. Washington (1908).

³"Production of Explosives in the United States During the Calendar Year 1920," William W. Adams, p. 21, Tech. Paper 291, U. S. Bureau of Mines, (1921).

⁴"America's Munitions 1917-18," Benedict Crowell, p. 115, Washington Government Printing Office (1920).

nitric nitrogen than sodium nitrate, it possesses in addition nearly 17.5 per cent of amino nitrogen.

The hygroscopic and deliquescent properties of ammonium nitrate have militated against its use as a fertilizer, since they cause it to tend to cake and liquefy in storage, transportation and use. These characteristics also interfere seriously with the efforts of the farmer to spread the material on the fields, and of the manufacturer to make use of it as a component of compounded fertilizers. With the development of the Haber and Claude processes for the fixation of nitrogen, ammonium nitrate may be produced in a pure condition in enormous quantities and there is little doubt that in the fertilizer industry, as has been done in the explosives industry, means will be devised by which its objectionable characteristics will be so overcome that its proved valuable qualities as a fertilizer may be availed of. It is to be noted that the proposed contract of Henry Ford for Muscle Shoals calls for an annual production of 110,000 tons.¹

EXPLOSIVENESS OF AMMONIUM NITRATE

In the seventeenth century Glauber knew ammonium nitrate, which he styled *nitrum flammans*.² Gmelin styled it also *flammender salpeter* and cites Marchand as stating that "when rapidly and violently heated, as for instance when thrown on a red-hot porcelain plate, it burns with a pale yellow light and very slight noise, and gives off water, nitrous and nitrogen gas. It explodes when thrown on red-hot charcoal." In Turner's *Chemistry*³ it is stated that "when this salt is exposed to fire, it liquefies, emits aqueous vapor, dries and detonates." But the most complete investigation was made by Berthelot.

BERTHELOT'S RESEARCHES

In 1869 Berthelot published his "*Nouvelle recherches de thermochemie*,"⁴ in which, on pages 77 to 82, he treated of the decomposition of ammonium nitrate by heat, pointing out that the reaction taking place might be such as to absorb heat or to evolve heat and that the character of the reaction was determined by the heat applied according to whether the temperature is moderate or is increased rapidly.

He also states, on page 78, that when a crystal of ammonium nitrate is thrown into a red-hot crucible it decomposes with a flash of light, indicating the disengagement of considerable heat.

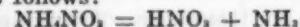
Berthelot returned to the consideration of this topic in 1875 in his "*Sur les oxydes de l'azote*,"⁵ where, on page 188, he recognizes five different modes of decomposition of ammonium nitrate, and again in 1877 in his "*Decomposition pyrogenée de l'azote*,"⁶ where he demonstrates the sublimation of ammonium nitrate and points out errors in the data of his former papers.

The results of his continued investigations are brought together and systematically presented in his "*Sur la force des matières explosives d'après la thermochemie*,"⁷

where, on pages 20 to 23 of vol. 1, we find the following:

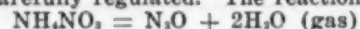
Thermal Decompositions: The decompositions which ammonium nitrate undergoes under the influence of heat are seven in number, as follows:

1. The dissociation or partial decomposition of fused or even gaseous ammonium nitrate into gaseous nitric acid and ammonia, which seem to be first produced and at a low temperature, as follows:



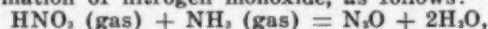
It takes place necessarily with absorption of heat—namely: —41,300 cal. when the solid nitrate is used, and about —37,000 when the salt is fused.

2. The formation of nitrogen monoxide (laughing gas) from ammonium nitrate at a higher temperature, and when the heat is carefully regulated. The reaction



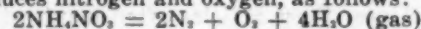
develops +10,200 cal. for the solid nitrate and about +14,000 cal. for the fused salt.

If the salt be supposed to have been previously decomposed into gaseous nitric acid and ammonia, and the reaction to have taken place between these two compounds with the formation of nitrogen monoxide, as follows:



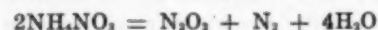
then this reaction would develop +51,500 cal.

3. When rapidly heated, the explosive decompositions, properly so called, of ammonium nitrate take place; one of them produces nitrogen and oxygen, as follows:



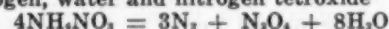
This reaction develops from the solid salt +30,700 cal.; and from the fused salt about +35,000 cal.

4. Or nitrogen and nitrogen dioxide may also be formed, as follows:



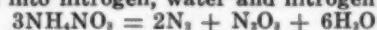
and +9,200 cal. is given off when the salt is solid and about +13,000 cal. when it is fused.

5. Heat is also liberated when ammonium nitrate gives rise to nitrogen, water and nitrogen tetroxide



+29,500 cal. being set free from the solid salt, and +33,500 cal. from the fused salt.

6. The ammonium nitrate may also be conceived as being transformed into nitrogen, water and nitrogen trioxide.



This reaction liberates +23,300 cal. from the solid salt, and about +27,000 cal. from the fused; but it never takes place alone, as nitrogen trioxide exists in the dissociated state only in presence of nitrogen dioxide and nitrogen tetroxide.

7. Lastly, ammonium nitrate can be resolved into gaseous nitric acid, nitrogen and aqueous vapor under certain influences such as that of spongy platinum



yielding +33,400 cal. from the solid salt and about +37,500 cal. from the fused.

Effects of Temperature and Rapidity of Heating:

These different modes of decomposition of ammonium nitrate, which may be separate or simultaneous, or, more exactly, the predominance of any one of them, depend on the relative rapidity and on the temperature at which decomposition is produced. This temperature is not fixed, but is itself subordinate to the rapidity of heating. It has been established by a great number of observations that each mode of decomposition of a given substance commences at a certain temperature and in a given time a limited weight of substance is decomposed.

Special stress is laid upon the singular property which ammonium nitrate possesses of undergoing several distinct modes of decomposition, according to the rapidity of heating and the temperature to which the substance is raised. Of these decompositions, some take place with liberation of heat, others with absorption of heat.

On pages 182 to 187 of vol. 2 Berthelot further discusses this topic and from the thermochemical data deduces the temperature and pressure developed in the decomposition of ammonium nitrate for each of the several reactions it undergoes.

Attention is first called to the fact that this salt begins to decompose at a temperature a little above 100 deg. C.

¹"Secretary Weeks Analyzes Ford's Offer for Muscle Shoals," *CHEM. & MET. ENG.*, vol. 26, No. 6, p. 274, Feb. 8, 1922.

²"A History of Chemistry," James Campbell Brown, P. Blakiston & Co., Philadelphia (1913), p. 206.

³"Handbook of Chemistry," Leopold Gmelin, translated by Henry Watts, Cavendish Society (1849), vol. 2, p. 490.

⁴"Elements of Chemistry," Edward Turner, 5th Am. ed., by Franklin Bache, Philadelphia (1835), p. 446.

⁵*Ann. chim. phys.*, vol. 18 [4], pp. 5-201 (1869).

⁶*Ann. chim. phys.*, vol. 6 [5], pp. 145-208 (1875).

⁷*Ann. chim. phys.*, vol. 10 [5], pp. 362-365 (1877).

⁸Third edition in two volumes, Paris, Gauthier-Villars, 1883.

while at the same time subliming in part. At about 200 deg. C. it is separated into nitrogen monoxide (laughing gas) and water without, however, there being a fixed temperature at which this reaction takes place. If the salt is superheated, and especially from 230 deg. C. upward, the decomposition accelerates itself more and more (nitrum flammans) and it ends by becoming explosive, while at the same time the salt becomes incandescent.

By thermochemical calculations Berthelot finds the theoretical temperatures developed under constant volume and the pressures developed for a given mass of the nitrate decomposed in its own volume with the water produced in the liquid or the gas phase. The highest results given are for reaction 3, in which the theoretical temperature is 1,501 deg. C. and the pressures, with water liquid, 3,200 kg. per sq.cm., and with water gaseous, 11,200 kg. per sq.cm. For reaction 4 the theoretical temperature is 518 deg. and the pressure, with water gaseous, 4,860 kg. per sq.cm. For reaction 2 the theoretical temperature is 555 deg. C. and the pressure, with water gaseous, is 4,500 kg. per sq.cm.

EXPLOSION IN CONFINEMENT

The direct explosion of ammonium nitrate *per se* through the use of an initiating agent was effected by Lobry de Bruyn¹¹ in 1891. For this purpose he employed a shell of 8-cm. caliber, weighing 7 kg., and a charge of about 2 kg. When the shell was loaded with ammonium nitrate and fired with a detonator containing 3 g. of mercury fulminate, the shell was burst and but sixty-two fragments, weighing about 6 kg., could be recovered. In a second experiment the shell was charged with 180 g. of ammonium nitrate primed with about 10 g. of bellite and fired by a detonator containing 1 g. of mercury fulminate. The shell was so comminuted by the explosion that but 230 fragments, weighing altogether 2.75 kg., could be recovered, as the rest of the shell had been reduced to powder.

In 1907 Lheure¹² compressed ammonium nitrate into cartridges under a pressure of 20 kg. per sq.cm. Three such cartridges, weighing 50 g. each, were confined in a bore hole in clay, by tamping them with 6 dm. of stemming, and they were fired by a piece of cordeau, 7.3 mm. in diameter, which traversed all three of the cartridges. The detonation of the ammonium nitrate was complete.

Pressure Developed: In his address before the Royal Institution on "Some War Developments of Explosives" Sir Robert Robertson¹³ gave a table of pressures developed by ammonium nitrate, amatols and TNT on explosion as determined by Bertram Hopkinson's pressure bar,¹⁴ in which it appears that while TNT developed on explosion a pressure of 55 tons per sq.in. in 0.5×10^{-3} seconds, ammonium nitrate developed a pressure of 12.5 tons in the same time.

Accidents Involving Ammonium Nitrate

The foregoing record shows beyond question that ammonium nitrate under certain circumstances is, by itself, explosive. This is true of many substances occurring in commerce, some of which are quite widely used. The question arises, Is ammonium nitrate to be regarded as an explosive and treated as such under all circum-

¹¹"Sur l'explosivité de l'azotate d'ammonium," C. A. Lobry de Bruyn, *Recueil des travaux chimiques des Pays-Bas*, vol. 10, pp. 127-131 (1891).

¹²"L'amélioration de la sécurité dans les mines grisouteuses par emploi d'un nouveau dispositif d'amorçage des explosifs," Lheure, *Annales des Mines*, Paris, vol. 12 [10], pp. 169-188 (1907).

¹³*Nature*, vol. 107, pp. 524-527 (1921).

¹⁴*Vide Proc. Roy. Soc., London (A)*, vol. 89, pp. 411-413 and *Trans. Roy. Soc., London (A)*, vol. 213, pp. 437-456 (1914).

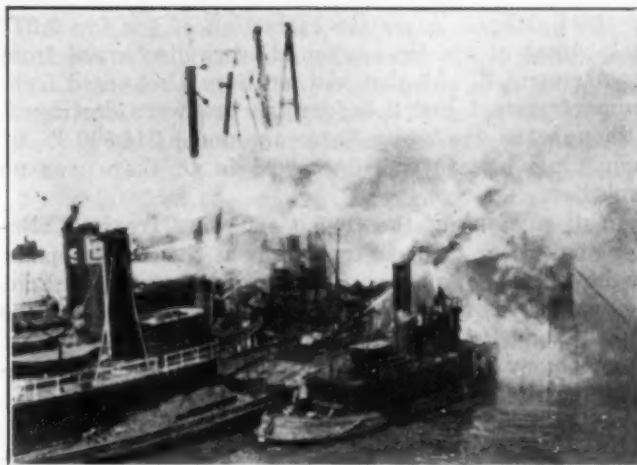


FIG. 1—EXTINGUISHING FIRE ABOARD THE STEAMER HALLFRIED*

stances? We may get the answer by consideration of accidents in which it was involved and from the results of tests.

There have been fires in which ammonium nitrate was involved, and in none of them, so far as the record goes, was there any explosion unless some other explosive was involved or unless material which could form an explosive mixture with ammonium nitrate was present. Thus at Barksdale, Wis., a building containing 30,000 lb. of ammonium nitrate stored in barrels on the floor was completely burned, yet there was no explosion and some of the ammonium nitrate was left unconsumed. But the most important instance, because of the quantity involved, is that of the steamer Hallfried.

FIRE ON STEAMER HALLFRIED

At about 12:40 noon, on April 14, 1920, a fire broke out in the forward compartment of the steamer Hallfried as she lay at Pier 5, Bush Docks, Brooklyn, N. Y., discharging cargo from all four of her compartments onto lighters alongside and when she had already discharged about one-third of her cargo. She had sailed

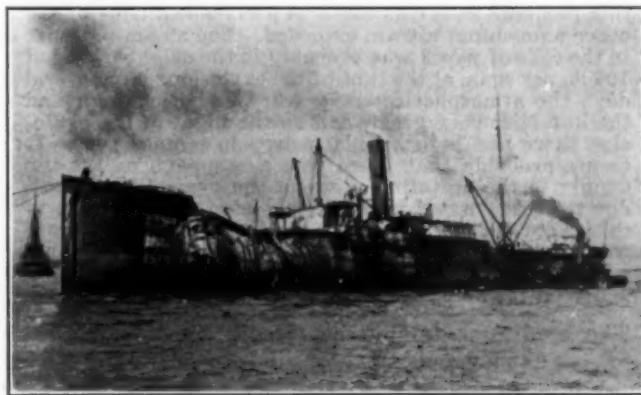


FIG. 2—STEAMER HALLFRIED AFTER THE FIRE WAS EXTINGUISHED

from Menstad, Norway, with a mixed cargo of raw skins, paper, ammonium nitrate, nitrate of soda and some chlorate, and it is believed the latter was the cause of the outbreak. There were on board 8,460 casks containing about 4,230,000 lb. of ammonium nitrite distributed among compartments 1, 2 and 3. Of this amount 3,111 casks were burned up in the ship and 778 casks

*Photos reproduced in Figs. 1 and 2 were supplied by the Merritt & Chapman Derrick & Wrecking Co., which extinguished the fire.

on the lighters. After the extinction of the fire 2,077 casks, most of which were sound, were discharged from compartment 3. All that had not been discharged from compartments 1 and 2 before the fire were destroyed. Although the fire was a fierce one and 1,944,500 lb. of ammonium nitrate was destroyed in it, there was no explosion.

In discussions of the Oppau explosion frequent allusions have been made to explosions at the Oakdale plant of the Aetna Co. and the Repauno plant of the du Pont Co., as well as to the explosion at Morgan, N. J. The Oakdale and Repauno explosions have a special interest in that they occurred during the manufacture of ammonium nitrate and its process of crystallization.

REPAUNO EXPLOSION

The circumstances of the Repauno explosion are described as follows by the director of the chemical division of the company in a private communication:

At 10 p.m. on Jan. 14, 1916, an explosion occurred in the ammonium nitrate evaporating and crystallizing plant of E. I. du Pont de Nemours & Co., located at Repauno Works, Gibbstown, N. J., inflicting heavy damage to the plant property and resulting in the loss of one life and more or less serious injuries to twelve employees, none of whom suffered permanent disability.

The plant consisted of a row of five evaporating pans and a row of five crystallizing kettles located parallel to each other and numbered consecutively from right to left when facing the pans with back to the kettles. The evaporating pans were separated from one another by a space of approximately 3 ft. and the kettles by a space of approximately 3 ft. and the row of pans was approximately 15 ft. distant from the row of crystallizing kettles. At the time of the explosion, evaporating pan 3 contained a charge of approximately 4,000 lb. of ammonium nitrate which had been about completely evaporated and was ready to be discharged into crystallizing kettles 1, 2 and 3. Evaporating pan 5 contained a charge of ammonium nitrate liquor which was being evaporated, the actual ammonium nitrate content of which was about 2,000 lb. Evaporating pans 1, 2 and 4 were empty.

Crystallizing kettles 2, 3 and 4 each contained approximately 1,000 lb. of ammonium nitrate. Kettle 1 had just been emptied and kettle 5 was not in use.

The explosion occurred in evaporating pan 3, as evidenced by a crater about 5 ft. in depth directly beneath this pan, and so far as could be ascertained none of the other ammonium nitrate exploded. The steam pressure in the coils of pan 3 was probably in the neighborhood of 100 lb. per sq. in. at the time of the explosion. For several days the atmospheric temperature had been high and the humidity very great, and on the night of the explosion there had been a sudden drop in temperature. It seems probable that there was a stoppage of the air supply to the agitating pipes in the evaporating pans, due to frozen water in the supply pipe, and that due to this failure of the air supply, molten ammonium nitrate was forced into the agitating pipes, under which confinement rapid local decomposition took place, which finally extended to the entire charge.

The conditions for overheating in the Repauno accident are analogous to those in the manufacture of laughing gas except that the latter affords an easier opportunity for that rapid application of a high-temperature source of heat which Berthelot states is likely to bring about explosive decomposition. Yet I have found but a single record of such an explosion, and this by Daniel,¹ who cites an accident at Kensington, March 20, 1896, following the heating of 18 lb. of ammonium nitrate in an enameled iron retort by Dr. Orchard, a dentist, for the purpose of producing laughing gas, when explosive decomposition set in and the plant was wrecked.

¹"Dictionnaire des matières explosives," J. Daniel, Paris (1902), p. 458.

OAKDALE EXPLOSION

The following description of the Oakdale explosion was supplied to the writer by Superintendent Johnson:

The accident occurred on Sept. 15, 1916, at 8:50 p.m. An explosion occurred in one of the pre-boiling tanks. There were three or four of these tanks, which sat on the side hill between the neutralizing tanks and the graining bowls. These tanks were approximately 4½ ft. wide, 3½ ft. deep and 8 ft. long. They were old crystallizing tanks from the Carnegie TNT plant. The explosion tore one of these tanks into small bits, the largest piece we found being three-quarters of a mile from the explosion. It weighed 173 lb. This was near the Greggs Station. Another of these tanks was found up the hill above the neutralizing tanks near the boiler house, or a distance of about 25 ft. higher on the hill, back approximately 50 ft. from its foundation. These tanks were ordinary boiler plate and were equipped with cast-iron coils, put together by rust joints.

For some weeks prior to this we had been trying to produce ammonium nitrate of 99 per cent or better purity for the government. We were using ammonia liquor, I believe, which was shipped us by The Barrett Co. or the Semet-Solvay Co. The nitric acid was a mixture of the weak from the still acid and the recovered nitric from the TNT spent. Only a very small proportion was still acid. Inasmuch as we had not been very successful in obtaining a high grade of ammonium nitrate, we decided about 10 days prior to the date of the accident that it would be necessary to empty and wash out the settling tanks, which were 10 x 10 wooden tanks. These settling tanks had been washed out and the charge that blew was the first one to be boiled down after they had been cleaned out. The charge was put into the tank some time during the day. It occurs to me that it was before noon. As we were very anxious concerning the results, Mr. Hutchinson, then acid foreman, and I made several visits and spent quite some time watching this particular charge. I was informed by Mr. Hutchinson that it was necessary to extinguish a small blaze on the charge several times during the day, although the liquor apparently had been thoroughly settled, judging from the appearance and the length of time, having been better than 4 days.

At the investigation after the accident, at which Messrs. Fox, Crewe and one or two others were present, it was decided that the accident was due to the TNT in the acid. While this may have been the explanation, Mr. Diehl and I concluded, after conversation with a couple of prominent chemistry instructors, that the accident was due to the presence of unstable nitrites, due to the excessively high oxides in the acid. This of course is usually found to be the condition of nitric acid recovered from TNT, and the assumption was based on some German literature to which reference has been made. I regret that I am unable to furnish these references at this time. Either explanation, however, is only theoretical, as the exact reason is not known. My reason for believing the latter theory was that the neutralized ammonia liquor had such a clear appearance that it seemed to me that this was a more reasonable explanation.

The explosion was felt for a distance of about 15 miles away; which will give some idea of the intensity of the blow. I think that approximately 3,000 lb. of nitrate of ammonia was in the exploding charge.

It might be well to point out that in both the Repauno and Oakdale cases weak nitric acid recovered from TNT waste acid was being used in manufacturing the ammonium nitrate. It is known that such weak acid contains nitro bodies and it is possible that these nitro bodies may have had something to do with initiating the explosions.

MORGAN EXPLOSION

Among the great disasters in which ammonium nitrate played an important part was that which occurred at the plant of the T. A. Gillespie Loading Co., Morgan, N. J. This started with a fire in the extruding plant for loading amatol into shells, which was situated in the northwest corner of the tract of 2,600 acres occupied by this plant. The fire started just before 8

p.m. Friday, Oct. 4, 1918, and continued to rage until the night of Oct. 5. At the time the fire broke out there was assembled within the above-mentioned area 30,855,076 lb. of explosives, some stored in magazines and some in loaded shell, part of the latter being in dumps on the ground and part on railway cars. Shortly after the fire started shells began to explode, many of them being projected to a distance before they exploded, and a fitful bombardment continued through Oct. 6, even after the general conflagration had ceased. In this disaster 12,155,839 lb. of explosive was destroyed. Among the materials at Morgan was upward of 9,000,000 lb. of ammonium nitrate. I visited the scene of this disaster on Tuesday, Oct. 8, as soon as it was at all possible to permit of inspection, and noted particularly the locations at which ammonium nitrate had been stored, observing in instances partly burned barrels and heaps of fused material surrounding barrels of this nitrate that were perfectly intact, but finding special interest in the enormous craters excavated at sites where storehouses containing ammonium nitrate had been located. One of these craters 150 ft. long, 140 ft. wide and 30 ft. in depth was exceeded, in one dimension only, by that at the site of a large dump of loaded shell, and also that at a place where three cars loaded with TNT had been parked.

There is no doubt whatever that the ammonium nitrate that was in storage at the locations cited detonated very completely. It is equally certain that ammonium nitrate stored at other sites within this area did not detonate or even explode, although exposed to fire and to the shock of the many heavy detonations which occurred within this area. Where so many factors obtain as in this case it is not possible to determine definitely the cause of the detonations of the ammonium nitrate that did occur, but considering all the circumstances it seems not improbable they were due to the explosion within the ammonium-nitrate storehouses of high-explosive shell loaded with amatol.

I have added to the information gathered in my visit by perusal of Congressional documents and the excellent report by F. Hawkes. The latter was in intimate touch with the Morgan plant from the beginning of its construction and throughout its operation. He was at the plant throughout the period of its destruction and observed its progress from its beginning to the end. He states that "all major explosions at the plant were preceded by flames which could be seen mounting higher and higher, in each case culminating in a huge column of smoke and flame, the shock of detonation reaching us a little time afterward." "It is certain that actual detonations of large amounts of ammonium nitrate took place at the destruction of the Morgan plant, these detonations being preceded by fierce fires, during the time when amatol-loaded shells were being projected or had been projected from other parts of the plant." "There were certainly no explosions of ammonium nitrate previous to those which occurred during the destruction of the plant."

Recent Tests of Ammonium Nitrate

I now present the results of tests which I have compiled from a mass of data supplied to me by F. C. Zeisberg of the du Pont company, covering not only the solid nitrate of commerce, but also the molten nitrate such as is found in the crystallizing pans.

Effects of Heating: Because of the explosions that had occurred in crystallizing pans during the manufac-

ture of ammonium nitrate, tests were made of both the anhydrous and the hydrous material in the molten condition, the first observations made being as to the effect of heat upon it. For this purpose 10 lb. of the salt, containing 99.11 per cent of ammonium nitrate and 0.08 per cent of moisture, was placed in a 10-qt. enameled kettle, a standardized base-metal thermocouple inserted in the salt, the kettle with its contents placed on an improvised cylindrical stove, in which was a coke fire, and heated. The temperatures in the mass were read by a millivoltmeter.

In the first tests the mass attained a temperature of 29 deg. C. in 1 minute and white fumes in small quantity were given off. In 4 minutes more the temperature had risen to 72 deg. C. and white fumes were given off in considerable quantity. In 1.5 minutes more the temperature had risen to 261 deg. C. and red fumes appeared mixed with the white ones. One minute later



FIG. 3—BURNING TEST WITH THREE BARRELS, EACH CONTAINING 500 LB. AMMONIUM NITRATE

the temperature observed was 289 deg. C. and at that point yellow fumes appeared mixed with the white. In 1.5 minutes more the temperature noted was 348 deg. C. and the fumes had begun to lessen. One minute later, or 10 minutes from the start, a temperature of 375 deg. C. was reached and the fumes had ceased. Close examination showed that all of the ammonium nitrate had disappeared, leaving the kettle empty. There was no explosion.

This test was twice repeated with some slight variations, but, though analogous rapid rises in temperature and volatilization of the ammonium nitrate, accompanied at the higher temperatures by red and yellow fumes, due undoubtedly to nitrogen oxides from thermolysis of the nitrate, occurred, there was no detonation in any instance. The only approach to an explosion was in test 2, in which an 8-in. length of 1-in. iron pipe, filled with freshly crystallized ammonium nitrate and closed at both ends with iron caps, which were screwed on them, was imbedded in the charge of ammonium nitrate in the kettle to serve possibly as a primer for the latter, for at the expiration 11 minutes and when the temperature had reached 318 deg. C. there was a slight report and flash. It was found that the pipe had been split, was appre-

ciably shattered, as was one of its caps also, and that the kettle was split, while some of the ammonium nitrate was found scattered on the ground. This latter suggested that the flash observed may have been caused by the projection of molten nitrate into the fire.

Sensitiveness of Molten Nitrate: Aqueous solutions of ammonium nitrate were evaporated to the crystallizing point, the temperature raised to insure complete liquefaction, and detonators or blasting gelatine exploded in the mass. The tests were conducted in open kettles and 10-lb. charges of ammonium nitrate were used. Although No. 8 detonators, singly and in groups of three, and 100-g. masses of explosive gelatine, primed with cordeau, were exploded in these "hot liquors," there was in no instance any approach to detonation on the part of the ammonium nitrate.

Pendulum Friction Test: Using 10 g. of fine-grained nitrate, containing 99.11 per cent ammonium nitrate and 0.08 per cent of moisture, on the steel anvil and a fall of 2½ m. for the steel shoe, negative results were obtained in 190 tests. There was no explosion or local crackling in any case.

Impact Test: In ten tests of the above-mentioned ammonium nitrate no explosions occurred when a weight of 20 kg. falling through a meter in height impinged upon the nitrate confined between steel surfaces.

Tests of Explosibility: Tests of explosibility were made on ammonium nitrate from different sources by firing a cartridge of blasting gelatine, exploded by cordeau, in contact with the nitrate.



FIG. 3—PENDULUM FRICTION TESTING MACHINE

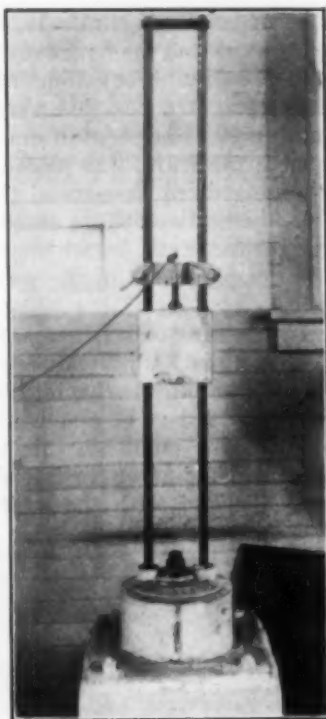


FIG. 4—IMPACT TESTING MACHINE

EXPLOSIBILITY TESTS

Kind of Am. Nitrate	Moisture Content Per Cent	Weight of Am. Nitrate	Weight of Blasting Gelatine	Result
German "as received"	0.26	15 lbs.	240 grams	Detonated
Brünner-Mond, "as received"	0.84	15 lbs.	240 grams	Partial detonation
No. 2 east.	1.45	40 lbs.	243 grams	Detonated
German, "as received"	0.16	135 lbs.	243 grams	Detonated and produced crater 12 ft. in diameter and 4 ft. deep.

EFFECT OF ADMIXTURE WITH AMMONIUM SULPHATE

Test of mixtures of No. 3 ammonium nitrate made from German ammonia with ammonium sulphate were



FIG. 6—DETONATION TEST OF 40-LB. KEG OF AMMONIUM NITRATE BY 240 GRAMS (½ LB.) CARTRIDGE OF BLASTING GELATINE

made in a similar manner to those just described, except that the charge was placed on a lead block, as described below. The two salts were mechanically mixed "dry."

EXPLOSIBILITY OF MIXTURES OF AMMONIUM NITRATE AND AMMONIUM SULPHATE

Parts of NH_4NO_3	Parts of $(\text{NH}_4)_2\text{SO}_4$	Weight of Blasting Gelatine, Grams	Result	Compression of Lead Block, Inches
90	10	100	Detonation	
90	10	75	Detonation	
90	10	50	No detonation	None
80	20	100	Detonation	
80	20	75	Detonation	
80	20	50	No detonation	None
70	30	100	No detonation	None
60	40	100	No detonation	None

SENSITIVENESS TO DETONATION BY BLASTING GELATINE

Tests of sensitiveness of ammonium nitrate to detonation by blasting gelatine were made by placing 400 g. of the dry nitrate in a beaker which rested on a lead block 4 in. high and 2½ in. in diameter. The firing was done with different known weights of blasting gelatine exploded in the ammonium nitrate by means of cordeau

SENSITIVENESS OF AMMONIUM NITRATE TO DETONATION BY BLASTING GELATINE

Weight of Blasting Gelatine, Grams	Result	Compression of Lead Block, Inches
100	Detonation	
75	Detonation	
50	Detonation	
25	No detonation	None

detonant and the effect on the lead block measured. The ammonium nitrate used was No. 3 made from German ammonia.

RELATION OF TEMPERATURE TO SENSITIVENESS TO EXPLOSION

The tests were made by placing 2-lb. charges of fine-grained ammonium nitrate, 99.1 per cent pure, in tin



FIG. 7—CONDITION OF KEGS AND CONTENTS OF AMMONIUM NITRATE AFTER FIRE AND WATER TESTS

Three kegs were supported over open fire in a closed room and were extinguished after 15 minutes through operation of automatic sprinkler device.

cans 4 in. in diameter by 5 in. in height, heating the can and contents in a paraffine bath to the desired temperature, placing this system on a lead block 2½ in. in diameter by 4 in. in height, then imbedding in the ammonium nitrate one or more No. 8 electric detonators and firing them. The results obtained were as follows:

Temperature of Nitrate, Deg. C.	Number of Detonators Fired in Charge	Result	Compression of Lead Block, Inches
21	8	No detonation	None
50	5	No detonation	None
50	6	Partial detonation	None
70	1	No detonation	None
92.5	2	No detonation	None
92.5	3	Detonation	¼

PROPAGATION OF DETONATION IN AMMONIUM NITRATE

For these experiments use was made in each case of a wooden trough, approximately 5½ in. square in cross-section and 10 ft. long, which rested on the ground. Such a trough held approximately 125 lb. of ammonium nitrate. Use was made of both warm nitrate having a purity of 99.64 per cent, moisture content 0.05 per cent and a temperature of 52 deg. C., and of cold nitrate having a purity of 99.19 per cent, moisture content 0.02 per cent and temperature of 21 deg. C. The warm nitrate was made use of to insure detonation and was placed at the initiating end of the train. The effect was determined by the size and extent of the crater produced beneath the box.

Test 1. The box was filled for a distance of 3 ft. with warm ammonium nitrate and the remainder with cold nitrate. Eight special tetryl electric detonators were imbedded in the warm nitrate and shot, but the caps only fired and there was no explosion of the nitrate.

Test 2. The above loading conditions were duplicated except that in place of the tetryl detonators a stick of blasting gelatine was used as the primer. A complete

detonation of the ammonium nitrate resulted, giving a crater 11 in. deep x 6 ft. 6 in. wide at the initiating end and 7 in. deep x 5 ft. wide at the opposite end. The total length of the crater was 13 ft.

Test 3. In this case the box was completely filled with warm ammonium nitrate and primed with two sticks of blasting gelatine. The crater was practically the same as in test 2—i.e., 10 in. deep x 6 ft. 6 in. wide and 7 in. deep x 5½ ft. wide and 13 ft. long; the chief difference being in the width of the far end of the crater, which may have been due to a higher order of detonation caused by the increased priming charge.

Test 4. Warm ammonium nitrate only was used in this test. In the center of the box, and for a distance of 2 ft., a layer of nitrate 1 in. deep x 5½ in. wide was maintained. From each end of this 2-ft. length ammonium nitrate was sloped up flush with the ends of the 10-ft. box. A stick of blasting gelatine was placed at one end and on firing, the first half of the ammonium nitrate train detonated, but the wave failed to propagate through the 2-ft. length of powder which was but 1 in. deep. The crater was 8 in. deep, 3½ ft. wide and approximately 4½ ft. long.

In general the results show that ammonium nitrate *per se* will propagate its own wave of detonation, but the force gradually falls off, as shown by the decrease in depth and width of the crater at the end opposite the priming charge. Test 4 also shows that the explosion



FIGS. 8 AND 9

Fig. 8 (above)—Setting for test of propagation of detonation with seven 40-lb. kegs of ammonium nitrate. (Center keg contained blasting cartridge as in Fig. 6.)

Fig. 9 (below)—Results of explosion in 7-keg propagation test. The bottom of center keg and some unexploded nitrate will be observed. Contents of other barrels scattered but not exploded.

wave failed to travel through a 1-in. layer of ammonium nitrate.

PRESENT CONCLUSIONS AND PLANS FOR FUTURE INVESTIGATIONS

Some of the tests described above and many other tests by fire were observed by Mr. Schoen, and they are described by him in a well-illustrated report.¹ He concludes "that ammonium nitrate offers very much the same fire hazard as sodium nitrate—that is, an indirect hazard through the liberation of oxygen at moderately high temperatures, which gas serves to intensify combustion and tends to increase the extent and spread of fire"—in which conclusion I concur.

There is need for a decision on the explosion hazard also and I believe from all the evidence thus far at hand we are justified in holding that ammonium nitrate when stored by itself in wooden receptacles and apart from explosive substances is, for transportation and storage, not an explosive.

There still remains much to learn as to the behavior of ammonium nitrate, especially when associated with other ammonium compounds, as at Oppau, and this topic will be made the subject of investigation by a special committee appointed by the National Research Council consisting of Charles P. Beistle, Bureau of Explosives, A.R.A.; C. A. Bigelow, Institute of Makers of Explosives; S. P. Howell, Bureau of Mines; Charles E. Munroe, National Research Council; C. G. Storm, Ordnance Department, U. S. A.; R. C. Tolman, Fixed Nitrogen Research Laboratory, and a representative of the Bureau of Ordnance, U. S. N., to be named later.

National Research Council,
Washington, D. C.

Legal Notes

BY WELLINGTON GUSTIN

Negligence in Explosion Cases Construed

In the consolidated cases of the Republic of France, the King of Great Britain and Ireland and the Aetna Explosives Co. against the Lehigh Valley Railway Co., the Supreme Court of New Jersey, the actions involved grew out of the same explosion. (114 Atlantic R., 242.)

Part of the claim of France was for benzene and wet guncotton in railroad cars on the Lehigh Valley dock. For this the jury rendered a verdict for France which was not questioned. But part of the claim of France was for wet guncotton in cars on the Central Railroad dock; part for picric acid, N. C. powder and cannon powder in cars in the barge Rockwell; and on these the verdict was against France, which appealed.

The claim of the King of Great Britain was for smokeless powder on barges, that of the Aetna Explosives Co. was for powder on a barge; the verdict was against these claimants, who appealed.

It was urged that if the jury was right in finding in favor of France for the benzene and wet guncotton on the Lehigh Valley dock, it must logically have found negligence with reference to the guncotton on the Central Railroad dock. But the court said this argument overlooks the fact that there was an element of negligence as to these explosives that was not present

in the case of the other explosives belonging to France. One of the causes of negligence alleged was the failure to provide adequate facilities and proper measures for removing and isolating cars which caught fire and cars loaded with dangerous explosives likely to explode in or near which fire might be discovered. And it might properly be found that there was no negligence on the part of the Lehigh Valley Railroad Co., so far as concerned the starting of the fire, and yet quite properly found that there was negligence after the fire started in removing or isolating cars on its dock. This theory of liability is not applicable to cars standing on the Central Railroad dock with which the Lehigh Valley had nothing to do, said the court, and the verdict against France was upheld.

The question of liability in the cases of Great Britain and the Aetna Explosives Co. was more difficult. It appears that the claimants' stocks of supplies were on barges which had, without right and apparently without knowledge of the railroad company, been tied up to the Lehigh Valley wharf, one barge to another, and after the fire started had cut loose and were being towed away. The court held that persons who tied their barges to other barges tied up to the wharf of another were guilty of trespass on the rights of the wharf owner. And he could properly assume, in the absence of notice to the contrary, that owners of barges loaded with dangerous explosives would not tie their barges to barges tied at the wharf and loaded with dangerous explosives in violation of harbor regulations, and hence was under no duty to them, and they were not entitled to recover damages for an explosion where a fire started at the wharf.

Orders by Commission Merchants for Foreign Corporations

A case of interest to foreign corporations contemplating the doing of or doing business in the State of New York comes from the Appellate Division of the New York Supreme Court (197 App. Div., 788). Action was brought by the Eagle Manufacturing Co., Inc., against Arkell & Douglas, Inc., for goods sold. One of the defenses to the action for the purchase price of the goods was that the plaintiff was doing business in New York in violation of the general corporation law.

The orders were taken by Malone & Nicholson, who were engaged on their own account in business as brokers or commission merchants in New York City. They represented a number of foreign corporations having factories, including the plaintiff. The lease of the premises occupied by the brokers was in their own name, as was also the telephone contract. The manufacturing firm had nothing to do with the running of this New York office or its expenses, and contributed nothing toward its maintenance. The only goods of the factory in the possession of the brokers were samples. The goods sold never passed through the broker's hands.

Further, the plaintiff never had any stock of merchandise in the State of New York, nor did it have any bank account or any offices there, nor did it keep any books in the state. The goods involved in the suit were sold f.o.b. factory in West Virginia.

By a vote of 3 to 2 the court held that this state of facts established as a matter of law that the plaintiff was not doing business in the State of New York as contemplated by statute, so that non-compliance with section 15 of the corporation law would prevent actions on contracts based on the brokers' orders.

¹"Ammonium Nitrate (NH₄NO₃)," A. M. Schoen, chief engineer, Southeastern Underwriters Association, Jan. 18, 1922, 7 pages.

X-Ray Data on Martensite Formed Spontaneously From Austenite

Coarse-Grained Austenite, After Fifteen Months at Room Temperature, Is Found Unchanged in General Appearance, but Has Become Very Hard and Magnetic—Its Present X-Ray Spectrogram Is That Characteristic of Very Fine-Grained Ferrite

By EDGAR C. BAIN

HULL'S METHOD of crystal analysis,¹ although usually applied to very fine-grained metal or powders, affords data for estimating grain size over quite a range. In general it could not compete with an actual grain count under a microscope, but several orders of grain size can be recognized quite definitely by the appearance of the bands of the film pattern. Furthermore, as we shall see, it is useful for grain study where the microscope fails entirely. The Hull method and its minor modifications have been amply described from time to time, but it may be fitting to consider how these grain size data are obtained.

X-RAYS FOR ESTIMATING GRAIN SIZE

If a single crystal is mounted in a monochromatic beam of X-rays after the fashion of the early workers,² a definite number of positions with respect to the beam

will be traced by the deflected beam. A single grain placed at random has small chance of being in a position to "reflect" the beam at all. Its chances depend upon the number of possible plane spacings in the crystal which exceed one-half the wave-length and upon the divergence of the beam. If we increase the number of differently oriented crystals in the beam, we propor-



FIG. 2—ORIGINAL AUSTENITE, $\times 41$. OBLIQUE ILLUMINATION. ETCHED WITH HNO_3

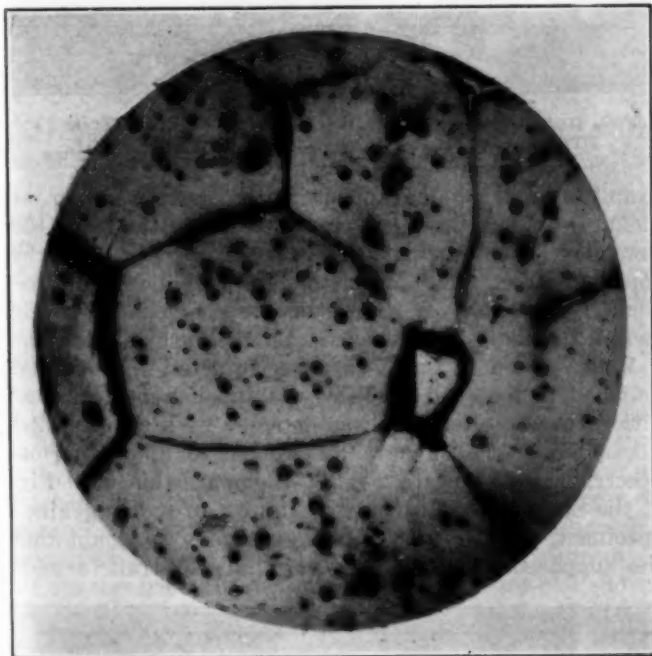


FIG. 1—ORIGINAL AUSTENITE. $\times 100$. ETCHED WITH HNO_3

will be found which will partly deflect the beam. In these positions a diffraction image of the source is projected in some direction. Assume the crystal to be in a position to produce an interference maximum and then rotate it with the beam as axis, and a conical path

tionally improve the chances for some diffraction image to be projected. Only a limited photosensitive surface is ordinarily provided to record these deflections of the beam, and if the area is small, it again lessens the number of reflections recorded. As an example, there are usually about five diffraction images recorded on the author's films from the mounted specimen whose grains are 1 sq.mm. in cross-section on the average.³ Such a dashed spectrogram is Fig. 8.

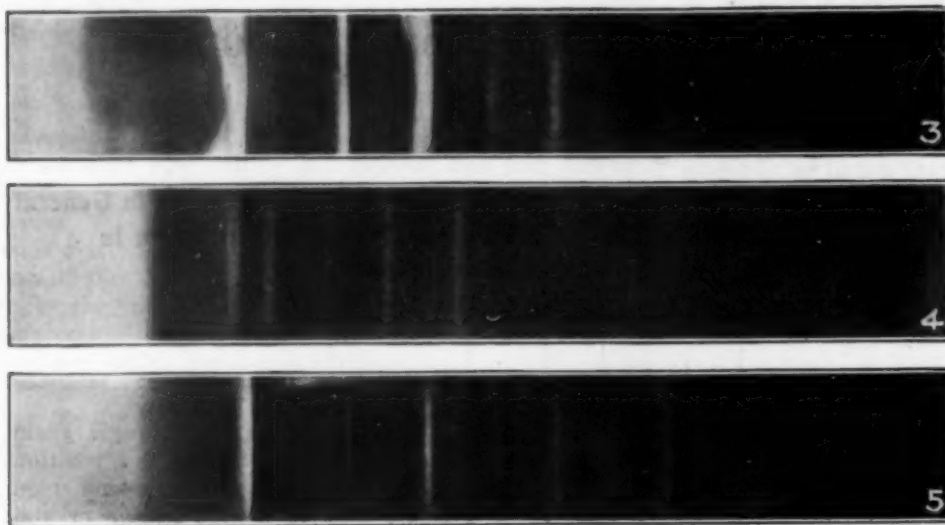
When there are sufficiently numerous grains or crystal fragments in the beam, the number of tiny images from similar orientations is so great that they overlap on the film and produce a smooth, evenly dark band. The largest grain size which can give this sort of band is of course the optimum for crystal study. This situation represents one general order of grain size and is easily recognized.

It may perhaps be of interest to note that as we refine the grain size still further we reach a condition at which the bands widen and lose contrast. This condition is realized very seldom indeed in metals, but doubtless crystalline fragments of colloidal size would yield such patterns. In general to keep the diffraction band from spreading over one degree in width the crystalline metallic fragments should have all gradations in size from 75 to 150 atom rows. To sum up then, with the very coarse structures we have only dashes on the

¹A. W. Hull, "The Position of Atoms in Metals," *Trans. A.I.E.E.*, 1919, vol. 38, Part 2, pp. 1445-1466; "A New Method of X-Ray Crystal Analysis," *Phys. Rev.*, vol. 10, No. 6, December, 1917; E. C. Bain, "Studies of Crystal Structure with X-Rays," *CHEM. & MET. ENG.*, Oct. 5, 1921, pp. 657-664.

²Bragg's "X-Rays and Crystal Structure"; G. W. E. Kaye, "X-Rays," Chap. 13.

³E. C. Bain and Zay Jeffries, "Mixed Orientation Developed in Crystals of Ductile Metals by Plastic Deformation," *CHEM. & MET. ENG.*, Oct. 26, 1921, p. 776. In this paper the use of the X-ray spectrometer for following grain size change is described.



FIGS. 3 TO 5

Fig. 3—Spectrogram of austenite after transformation to martensite.

Fig. 4—Spectrogram of austenite. Ordinary grain size.

Fig. 5—Spectrogram of pure ferrite, fine grain.

film which gradually become smaller with grain refinement until narrow continuous bands are produced. With further reduction in crystal size we gradually widen the smooth band.

According to the slip-interference theory advanced by Jeffries and Archer,⁴ martensite is necessarily a fine-grained material. Regardless of the apparent grain size of the material, which is in reality the grain size of the parent austenite, it probably derives its hardness from the resistance to slip which very fine crystal fragments offer. Of course, the useful martensite of good practice is extremely fine-grained even as to microscopic appearance, being transformed from a fine-grained austenite. But if it could be shown that specially prepared martensite from coarse-grained austenite was



FIG. 6—SAME AREA AS FIG. 2 AFTER TRANSFORMATION

also fine-grained, the theory would be enormously strengthened. The data offered below point conclusively to this situation.

It so happens that the specimens which exhibit such definite information on the state of aggregation of martensite also present the rarely noted spontaneous production of martensite from austenite

⁴Zay Jeffries and R. S. Archer, "The Slip Interference Theory of the Hardening of Metals," *CHEM. & MET. ENG.*, June 15, 1921, p. 1065.

at ordinary temperatures. The analysis of the steel employed for these studies is as follows:

	Per Cent
Carbon	0.32
Manganese	0.57
Phosphorus	0.031
Sulphur	0.013
Silicon	0.13
Nickel	2.81
Chromium	0.06

The specimens were produced by Prof. Chas. Y. Clayton of the School of Mines, University of Missouri, who supplied the analysis.

During the fall of 1921 the author received from Prof. Clayton some steel, presumably extremely coarse austenite, which had been prepared,

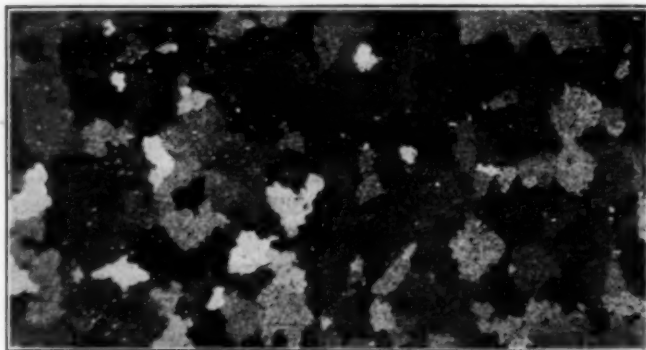


FIG. 7—SURFACE OF COARSE TUNGSTEN INGOT, $\times 7\frac{1}{2}$. ETCHED WITH NaOH. OBLIQUE ILLUMINATION

examined and photographed in the early summer of 1920. Fig. 1 is the micrograph of the austenite at 100 diameters with vertical illumination and Fig. 2 is the same specimen at $4\frac{1}{2}$ diameters with oblique illumination, both made at that time. The characteristic twinned crystals of quenched austenite are in evidence.

When placed in the X-ray spectrometer, the original polished and etched surface was in such perfect condition that no alteration was detected by a small pocket glass, but the author was astounded to find a normal spectrogram of ferrite, Fig. 3. Compare this with Fig. 4, the spectrogram of pure austenite in a fine-grained specimen. A test with the magnet gave no doubt that the supposed austenite was very largely transformed.



FIGS. 8 AND 9

Fig. 8—Spectrogram of coarse tungsten ingot shown in Fig. 7.

Fig. 9—Spectrogram of tungsten, fine grain.

For further comparison, Fig. 5 shows the spectrogram of a very fine powder of pure iron (ferrite).

Obviously the period of 15 months had been sufficient to convert the austenite to martensite at ordinary temperatures. Fig. 6 shows the same area as photographed in Fig. 2 after the transformation had taken place. At this magnification the macrostructures may be said to be identical.

Gradual change of austenite to martensite at ordinary temperatures has been observed by Honda and Idei.*

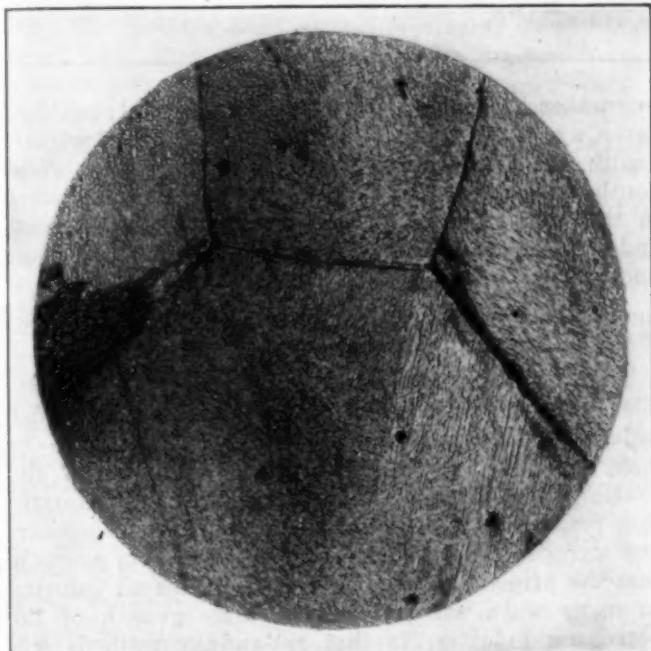


FIG. 10—MARTENSITE FROM SPECIMEN USED FOR SPECTROGRAM IN FIG. 3. $\times 100$. ETCHED WITH PICRIC ACID

They measured the progress of the transformation by the increase in hardness as time elapsed. However, the starting material in that case was a mixture of austenite and martensite, while the material studied here was undoubtedly entirely austenite. The hardness history of these specimens is not at hand, but the changed material is 555 Brinell as against 652 for martensite of the same steel prepared as such at the same time as these specimens were treated to produce austenite.

FINE-GRAINED DESPITE APPEARANCES

But the data show more than the spontaneous transformation. Fig. 7 is a photograph at $7\frac{1}{2}$ diameters of a small ingot of coarse tungsten. It is obviously of somewhat finer grain size than the original austenite preserved in the martensite. Yet its spectrogram is the characteristic dashed one described above and shown in Fig. 8.[†] *The film of the martensite is not at all characteristic of such coarse-grained material, though derived from an apparent grain size which was larger.* The microscope here has proved misleading for true grain-size determination.

However, there is an interesting appearance in a deeply etched area of the martensite at 100 diameters. Fig. 10 is a micrograph of the same area which had been exposed to the X-rays. Within the original well-marked grains there appear very plainly discontinuities of etching figures. While these configurations could scarcely

represent the new grain size of martensite, they do show that the region within the grain is a complex. On the other hand, the transformation, taking place at ordinary temperature, was probably very slow and might therefore give rather large areas of crystalline continuity. Perhaps in this one detail it is not representative martensite.

SUMMARY

To summarize, we find in martensite an apparent grain size somewhat larger than that of a truly coarse-grained tungsten ingot which yields a pattern characteristic of a very fine-grained metal. The old grain boundaries do not inclose single orientations, but many crystal fragments which result from the allotropic transformation of the gamma iron arrangement to the alpha iron arrangement. This fact corroborates very conclusively the theory of the fine-grained nature of martensite.

Cleveland, Ohio.

German Substitutes for Ferromanganese

Efforts of the Germans to procure high-grade manganese ore from foreign countries during the war had very little success. The main sources of supply before the war were Russia (from which nearly 400,000 tons was imported in 1913), British India, Spain and Brazil. All those supplies stopped at the beginning of the war. Small quantities of manganese ore were then imported from Sweden, but this was entirely insufficient.

For this reason steel production was dependent almost entirely upon reserves of manganese already accumulated in the country. Greatest economy was required, and for this reason the available foreign ore was mixed with German ore. Increased production of the latter was taken energetically in hand. The main deposit to draw from was the hematite of the Lahn Valley, but even the iron ore in the Sieg district, containing a small percentage of manganese, was largely used by steel works.

Apart from this, ferromanganese was made from the so-called Siegerland slag, from blast furnaces smelting Sieg ore, a slag containing from 8 to 9 per cent of manganese. Vast supplies of this cinder, sufficient for many years, were available. This ferromanganese was called "Siegerland chip steel," and was produced by the blast furnaces being burdened with two-fifths Siegerland slag and three-fifths iron scrap or turnings. Slag obtained at the Austrian Steel Works in Donawitz was even better for such purposes.

All efforts to find a substitute for manganese for the deoxidation of steel proved futile. The industry so far succeeded, however, in adapting the deoxidation process to low-grade spieghels and ferros that they were able to produce satisfactory results with the means at their disposal. Good results were obtained by using the deoxidation agent in liquid state. It should be mentioned that ferro-aluminum, containing from 15 to 20 per cent aluminum, was used during the war for a deoxidizer.

Since the war the importation of manganese ore has again been resumed, but the main sources of pre-war supply are not drawn upon, Sweden and Spain now furnishing most of the tonnage. These imports are in no way equal to the pre-war imports, no doubt due to the considerably reduced steel production, but also to the fact that the experience gained during the war has made Germany's steel industry less dependent upon foreign manganese ore.

*Kotaro Honda and Sakae Idei, "On the Distribution of Hardness in Quenched Carbon Steels, and Quenching Cracks." *Science Reports*, Tohoku Imperial University, First Series, vol. 4, No. 6, December, 1920.

[†]Fig. 9 represents the spectrogram for fine-grained tungsten.

The Problems of the American Shale-Oil Industry

An Outline Intended to Show Briefly the Present State of Our Knowledge in Various Divisions of the Field of Oil-Shale Technology and to Suggest Some Channels Which Future Investigational Effort May Take

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THE one fundamental problem of the shale-oil industry may be stated in a sentence: it must make money from oil-shale. Expressed more specifically, it must afford products, and especially staple products of value to civilization, at the lowest possible cost. Its object is not to produce oil from shale with high thermal efficiency, high recovery of saturated oils, or under ideal conditions in any other respect, except in so far as this can be done in such a way as to supply commercial demand at low cost. The real problem, then, is to obtain all necessary fundamental information on our American oil-shales by systematic research; to develop industrial-scale apparatus which is suited to deal with these shales, simple and economical in operation, and based on sound scientific principles; to refine the crude oil thus obtained into staple products for which there is a ready market; to develop markets for such products of the industry as cannot find an advantageous sale under present conditions; and so to organize the various processes involved that oil-shale may be turned into profit.

OIL-SHALE AN INDEFINITE TERM

It should be emphasized strongly at the start that "oil-shale" is a term which is even more indefinite than petroleum. Certain shales, for example those of New Brunswick, yield crude oils of relatively non-paraffinaceous mixed base, whose nature is such that their refining may not be effected economically with recovery of any other products than motor fuels and fuel oil, while, on the other hand, crude oils containing large percentages of paraffine may be obtained from such shales as that at Elko, Nev., and offer refining possibilities of an entirely different nature. In fact, it may be said that the most outstanding characteristic of oil-shales is their variability. Obviously, oil-shales may be classified as above on the basis of their destructive distillation products. It has also been suggested by W. A. Hamor that a more logical classification might be made on the basis of the predominating hydrocarbon minerals associated with various oil-shales whose distillation products are generally similar to those from the accompanying oil-shales. For example, Arcadian shale might be classified as albertitic; Australian, coorongitic; Kentucky, grahamitic; Scottish, torbanitic; and Colorado, gilsonitic.

When it is considered that it is possible to produce a considerable variation in the crude oil from any one of these oil-shales by varying the conditions of retorting, it is seen at once that a complete solution, if possible, of the problems of producing finished products from a given shale will by no means represent any solution of the problems of the American shale-oil industry. The folly of reasoning from one oil-shale

to another by analogy has been demonstrated; perhaps never more clearly than in the case of the Commonwealth Oil Corporation, formerly operating in New South Wales. Complete Scotch retorts were installed in this case, without proper preliminary experiment, and soon had to be abandoned because of their inapplicability.

GROWTH OF OIL-SHALE INDUSTRY LIKELY TO PARALLEL THAT OF THE PETROLEUM INDUSTRY

The fundamental ignorance of the properties of shale-oils produced from various American shales under different conditions, the uncertainty with regard to many questions as to the origin and nature of the shales themselves, and the dearth of scientific information respecting the hydrocarbons and oxygen, sulphur, and nitrogen compounds present make it seem probable that the primary development of the shale-oil industry in many ways will parallel the early growth of the petroleum industry, in that cut-and-try methods will be more in evidence than the intelligent application of scientific principles. A scientific principle must be established before it can be applied. However, the technical man will be more conspicuous than in the early petroleum industry, both because the processes involved in recovering and refining shale-oils are more complicated than those encountered in petroleum work, and because the shale-oil producer must face a market which, while not knowing exactly what it wants in all cases, nevertheless is educated beyond the wildest dreams of the early petroleum pioneers. Both these factors must influence profoundly the methods of attack upon the problems of the industry. It is interesting to note that, in 1860, the problem confronting the petroleum industry was to educate a public accustomed to lamp oil from crude coal-oil to the use of kerosene from petroleum, while the situation faced by the prospective shale-oil producer in many ways is practically the reverse of this.

OTHER PETROLEUM SUBSTITUTES WHICH MAY COMPETE WITH SHALE-OIL PRODUCTS

It is difficult to consider the problems of the shale-oil industry without at the same time taking into account the problems involved in the development of substitutes for petroleum and its products from other sources, such as the low-temperature distillation of coal, lignite, peat and miscellaneous organic materials. The effect of these products on the industry will be to limit the prices to which shale-oil products can rise after competition from natural petroleum has been eliminated by exhaustion of supply. However, the production of these low-temperature tars need not hinder the development of a shale-oil industry, inasmuch as the field is large

enough to accommodate all possible substitutes for petroleum. If there were at the present time a low-temperature carbonization industry of the proportions of the present byproduct coke industry, with a ready-made technology of preparing satisfactory petroleum substitutes economically, such an industry could supply less than 5 per cent of the current national demand for petroleum. To be sure, the byproduct coking industry is expanding rapidly, but this will afford some conception of the impossibility of supplying our future needs for petroleum by low-temperature carbonization alone. On the other hand, alcohol represents a different type of competing product, in that its production is limited only by price and demand, so that it may reasonably be assumed that ultimately the limiting price for motor fuels will be fixed by the price of alcohol. Again the statement must be qualified by the consideration that, until economic conditions are such that tropical vegetation may be used as a source of raw materials, potential alcohol production from the various available domestic sources, and especially from foodstuffs, is not sufficient to dominate the motor-fuel market. It is not the province of this paper to discuss the influence of these related products on the future of the shale-oil industry; but they are mentioned to direct attention to the facts that the production of oil from shale by destructive distillation is fundamentally an economic compromise, that its problems are economic problems, and that, for their proper solution, some acquaintance with these related fields, and especially the development of much information not yet available in these fields, will be necessary.

NO ONE SOLUTION FOR ALL CASES

Further, in solving problems which do come up, it is manifestly impossible that one solution will fit all cases. Not only will local variations in transportation, climate, water supply and demand for products largely influence the methods used in treating various shales, but the inherent variations in the oil-shales themselves are so great that the utmost caution must be exercised in applying proved facts regarding one shale to other shales, or in forming generalizations based on limited evidence.

On the other hand, there are many fundamental problems which can be solved without the expense incidental to repeating research work on a large number of shales. For example, most American shale-oils appear to have certain characteristics in common, such as their relatively high percentage of unsaturated compounds, their objectionable odor, their characteristic oxidation colors, and the presence of nitrogenous alkaloidal tars of high molecular weight. Each of these characteristics suggests certain fundamental problems which can be solved by working on a limited number of shale-oils.

The outline of the problems of the oil-shale industry which follows does not aim to deal further with the details of many of the economic problems which must arise; but it is intended to show very briefly the present state of our knowledge in various divisions of the field of oil-shale technology and to suggest some channels which future investigational effort may take, both in the development of commercial processes and in the collecting of fundamental scientific information. It is intended to be suggestive rather than inclusive in its scope.

The material listed has been divided logically into

(1) problems for pure-science research and (2) technological problems to be met.

I. Problems for Pure-Science Research

A. The Study of the Nature of Kerogen

1. MORPHOLOGY, MICROSCOPY AND PHYSICAL CHARACTERISTICS

These subjects belong rather to the field of the geologist and petrographer than to that of the chemist. However, the study of the nature of the material from which the kerogen originated and of its various forms must precede definite chemical study; it will also suggest the most profitable lines of attack from a purely chemical standpoint. The field has by no means been exhausted, but work now being done along these lines by Dr. Reinhardt Thiessen,¹ of the United States Bureau of Mines, should add much to our knowledge of American shales.

2. THE CHEMICAL NATURE OF KEROGEN

(a) Separation of kerogen from inorganic material.

(1) By flotation. This has been attempted at the Mellon Institute, but without much success. Starting with a material containing 65.8 per cent ash, a concentrate containing 61.25 per cent and tailings containing 68.68 per cent ash were obtained in a Callow cell, using a small amount of pine oil as the flotative agent. While it is possible that different conditions may effect greater concentration, it is not probable that ash-free kerogen can be prepared in this manner.

(2) By gravity separation.

(3) By the Trent process.² This has been attempted by the U. S. Bureau of Mines, with results very similar to those obtained in the case of flotation.³

(4) By heating oil-shale under high-pressures, with the idea of using pressures sufficiently high to retard the formation of oil vapors, which would be accompanied by increase in volume. Negative results were obtained by this method, up to 1,600 lb. per sq.in. pressure.⁴

(5) By the action of solvents on the kerogen. No known solvent seems capable of effecting such a separation; hence the action of solvents is included below under the chemical study of kerogen, rather than under its separation from ash.

(6) By the action of solvents on the ash. Numerous attempts have been made by various investigators to dissolve the ash from finely divided shale by means of acids, with only partial success. Alternate treatments with hydrofluoric acid and aqua regia seem to be most effective, but even these are not capable of reducing the ash content to zero, and the kerogen seems to be considerably altered by the chlorinating and oxidizing action of the aqua regia. Hydrofluoric and hydrochloric acids, alternately used, do not change the kerogen so much.

(b) The study of the chemical nature of kerogen as shown by its reactions. In general, it may be said that the investigations of the chemical constitution of coal could be repeated profitably on oil-shale, if its chemical nature is to be elucidated and its exact relation to coal fixed definitely. As a guide for this work,

¹See, for example, *Bull. Geol. Soc. Am.*, vol. 32 (1921), pp. 72-3; or *Econ. Geol.*, vol. 16 (1921), pp. 289-300.

²On the Trent process, see Bacon and Hamor, "American Fuels," vol. 1, McGraw-Hill Co., 1922.

³Private communication.

⁴Unpublished work, Mellon Institute of Industrial Research.

the review of the literature on the constitution of coal prepared by Wheeler and Stopes⁶ is valuable, while the later work of the Kaiser-Wilhelm Institut für Kohlenforschung⁷ is suggestive in many cases. Some lines of purely scientific research which should be covered are indicated as follows:

(1) Ozone has been used to produce considerable percentages of water-soluble materials from coal, but its action on oil-shale has never been studied.⁷

(2) Studies of the solvent action of the following and other solvents should be extended to cover a larger number of shales. Especially should uniform conditions of extraction be established, and the properties of the products obtained reported in terms which would permit some comparison of the work of different investigators.⁸

- (a) Pyridine,
- (b) Aniline,
- (c) Phenol,
- (d) Liquid sulphur dioxide,⁹ and
- (e) Liquid ammonia, suggested by the presence in oil-shales of complex nitrogen compounds which reasonably could be expected to be soluble in it.

The solvent action of the ordinary bitumen solvents is so slight as to offer little promise of yielding any significant results; but extractions at relatively high temperatures and pressures with benzene, carbon bisulphide, chloroform and carbon tetrachloride might give interesting products. In this connection a study from a quantitative standpoint of the adsorption of crude shale-oils or extracted bitumen by finely divided clays is needed, for the percentage of material dissolved out of a shale by any of these solvents bears no necessary relation to the percentage of soluble material present, owing to adsorption effects.

(3) Studies should be made of the solvent action of various reagents which react chemically with the kerogen. Some of the solvents listed under (2) may be placed in this class.

(a) Selenium oxychloride. Preliminary work has been done with this compound by a number of investigators, but it seems to so alter the kerogen as to offer small hope for any clean-cut results.

(b) Sulphuryl chloride is said to be superior to selenium oxychloride in many respects, some work having been done with it as well.

(c) Acetylation, sulphonation, nitration and chlorination may be carried out on the oil-yielding substance, but so far as is known the products have never been examined. In some cases—e.g., nitration—it is necessary to employ a solvent to extract the products formed.

(d) The kerogen forms a dark colored complex with sulphuric acid,¹⁰ at 110-120 deg. C. The study of this product might throw further light on the chemical nature of kerogen.

(e) Determination of methoxyl content.¹¹

⁶Wheeler and Stopes, "The Constitution of Coal," Department of Industrial and Scientific Research, London, 1918.

⁷"Gesammelte Abhandlungen zur Kenntnis der Kohle," Mulheim am Ruhr, 1916, et seq.

⁸See Fischer and Niggeman, "Gesammelte Abhandlungen zur Kenntnis der Kohle," vol. 1 (1917), pp. 30-42; also *Ber.*, vol. 49 (1916), pp. 1472-4.

⁹As an example of the importance of clearly defined and uniform methods of extraction, see Bone and Sarjant, *Proc. Roy. Soc., London*, vol. 96A (1919), pp. 119-36; and *Chem. Abs.*, vol. 14 (1920), p. 111, on the influence of the access of oxygen and of various physical conditions on the extraction of coal substance with pyridine.

¹⁰Cf. Fischer and Glund, *Ber.*, vol. 49 (1916), pp. 1469-74.

¹¹See Marcusson, *Chem. Zeit.*, vol. 42 (1918), pp. 437-9, on the formation of similar complexes from coals.

¹²Cf. Fischer and Tropsch, "Gesammelte Abhandlungen zur Kenntnis der Kohle," vol. 2 (1917), pp. 151-3.

(c) The study of the chemical nature of kerogen as revealed by ultimate analyses. Very few ultimate analyses are now available on oil-shales from various parts of the United States.¹² If the importance of the ultimate composition of kerogen in its influence on the quality of oil formed were established, an incentive would be provided for obtaining other information of interest. The oil-shale laboratory of the U. S. Bureau of Mines is now studying the ultimate composition of oil-shales.

(d) The hydrolysis of kerogen. In many shales the exines of lycopodiaceous spores are quite numerous, and the microscopic evidence on this point seems good, but it is not so well established chemically. Steuart,¹³ who made an "artificial shale" from lycopodium spores and fullers earth, obtained crude oil from it very like Scotch shale-oil in gravity and setting point. Evidence of the presence of fatty acids in oil-shale or their production from it by hydrolysis would be more nearly conclusive.¹⁴

THERMAL DECOMPOSITION OF KEROGEN

(e) The thermal decomposition of kerogen. The work of Jones and Wheeler¹⁵ on the distillation of coal in vacuo should be carried out on oil-shales. This would involve slow distillation at a pressure of, say, 20 mm., raising the temperature in 50 deg. steps, each step to last long enough for equilibrium to be established. Of course fractions should be separately examined.

The results to be obtained should include the following for each step:

(1) A complete gas analysis, including the determination of olefines heavier than ethylene, and fixing the temperature limits of the evolution of each constituent of the gas.

(2) An examination of the aqueous distillate for ammonia, pyridine and higher bases, and especially for other water-soluble compounds. It has been noted that when oil-shale is distilled at atmospheric pressure, foul-smelling sulphur compounds distill over with the aqueous distillate considerably below the temperature of first oil formation. The suggestion is obvious that some of the compounds responsible for the offensive odor of shale oils are produced by the destructive distillation of a material in the shale distinct from the oil-yielding material. However, practically nothing is known of these changes.

(3) The distribution of nitrogen among the water, the oil and the gas.

(4) The examination of the oil to determine the important physical constants, ultimate composition and constituents soluble in alkali and in dilute acid.

B. Fundamental Research on the Hydrocarbons, Oxygen, Nitrogen and Sulphur Compounds Present in Shale-Oils

This section of the problems of the industry is related so closely to the needs of the petroleum and coal-tar industries along the same line that only a few questions, more or less peculiar to shale-oils, will be taken up. Some idea of the lack of information on the great majority of the compounds present in mineral

¹²See Winchester, U. S. Geol. Surv. Bull. 641-F, for a few ultimate analyses of American shales; and Botkin, *Chem. & Met. Eng.*, vol. 24 (1921), pp. 876-80, on the relation between ultimate analysis and quality of oil.

¹³Steuart, *Mem. Geol. Surv. Scotland*, "The Oil-Shales of the Lothians," 1912, p. 164.

¹⁴Langer has reported in *Arch. de Pharm.*, vol. 27 (1889), pp. 241-65 and 289-309, a series of experiments on *Lycopodium clavatum*, which support this contention.

¹⁵*J. Chem. Soc.*, vol. 97 (1919), pp. 99 and 649.

oils may be gleaned from numerous contributions to the literature.¹⁴ The case for further research on non-benzoid hydrocarbons has been stated by Brooks.¹⁵ Scientific inquiry along these lines would be of direct assistance to the shale-oil industry.

Among the subjects of pure-science research of especial interest in connection with shale-oils are the following:

(1) All shale oils appear to contain nitrogenous tars of high molecular weight. The particular interest attached to them lies in the fact that they comprise a large part of the relatively large loss suffered in refining shale-oils, and may constitute as much as one-fourth part by weight of the oily distillate.¹⁶

While it is believed that the various series of nitrogen compounds may extend from their simplest members through heavier tars to solid compounds stable at high temperatures,¹⁷ little is known of any but the lowest members.

It is possible to hydrolyze tars obtained from some shale-oils, with the production of simpler nitrogen bases, and it seems quite probable that a better knowledge of some of the higher nitrogenous compounds may suggest a commercially feasible process of cracking or treating them to produce non-nitrogenous oils, or at least products of value. As is well known, at the present time the Scotch acid-tars, which are made up largely of these nitrogenous compounds, are burned.

Other possibilities are suggested by the fact that some of these tars, as well as the "asphaltenes" separated from crude shale-oils by means of petroleum ether, are quite soluble in 95 per cent ethyl alcohol. This behavior suggests a fundamental point of difference from petroleum asphalts, which indicates a probable difference in other properties as well.

(2) Many shale-oils, and perhaps all, yield light distillates which rapidly oxidize in sunlight to a wine color. The nature of this coloring material is quite unknown, but research on it may lead to valuable results.

It is suggestive that the material is soluble in dilute ethyl alcohol, is reduced to a colorless compound (leuco base?) by sodium hydrogen sulphite, and is red in acid, but colorless to yellow in alkaline solutions.

(3) The closer study of the gum-forming materials in shale-oil gasolines from a purely scientific viewpoint, and the establishment of the relationships between these and similar compounds in pressure distillates from petroleum should be attempted. The work of Steuart¹⁸ will furnish a starting point.

II. Technological Problems

A. Mining Problems

Our present knowledge of the mining of oil-shale is restricted to the Scotch oil-shale industry. Many favorable factors make it appear that the mining of oil-shale will present no insurmountable problems, but, as in any industry whose profits depend upon tonnage, a big field is open to the engineer's skill in lowering costs by efficient handling of materials.

¹⁴See, for example, Gurwitsch, "Wissenschaftliche Grundlagen der Erdölverarbeitung," pp. 1 seq.

¹⁵CHEM. & MET. ENG., vol. 22 (1920), pp. 933-7.

¹⁶Belby, J. Soc. Chem. Ind., vol. 3 (1884), p. 216.

¹⁷Belby, *ibid.*

¹⁸Steuart, J. Soc. Chem. Ind., vol. 18 (1899), p. 239.

B. Crude-Oil Works Problems

In the crude-oil works also, methods of handling materials will play an important part. However, the fundamental problems are two: What retort shall be used? And under what conditions shall it be operated?

A number of variously designed retorts have been operated in Scotland and elsewhere. While it is not the function of this paper to discuss their development through the periods when burning oils, paraffine and later ammonium sulphate were the principal desiderata, it should be emphasized that a thorough study of these retorts is a necessary preliminary to any proper consideration of the problems before the American shale oil industry.

During the past five years there has been an almost continuous flow of designs for oil-shale retorts into the U. S. Patent Office. These applications include many permutations and combinations of various simple elements, most of which are by no means novel, but many possible arrangements have been overlooked. Owing to this fortuitous circumstance, it is still possible to invent an oil-shale retorting process, and the enthusiasm of prospective inventors should by no means suffer any diminution.

It should be noted, however, that the success or failure of the considerable number of processes which seem to be designed upon sound principles will be based not upon the sublime inspiration embodied in the patent specifications so much as upon the intelligence with which mechanical difficulties are overcome, and upon the care and technical skill shown in determining and regulating conditions of operation. It is probable that at least a half-dozen of the processes proposed to date are fundamentally sound enough to survive competition if applied to retorting a shale under conditions to which they are suited, and if they are developed intelligently to the point where continuous and economical operation can be obtained.

In accordance with this view, the effort has been made to list only problems which appear to be fundamental. For example, if a certain oil-shale seems to require stirring in thin layers, it may make small difference whether it be stirred in A's agitated retort or in B's, provided that the mechanical efficiencies and operating advantages of the various agitating devices are the same, and assuming good engineering.

1. RETORTING PROBLEMS

(a) What is the best practice in crushing oil-shale before retorting?

It is impossible to present this problem as a general one, as the optimum size of particles depends to a large extent upon the retort which is to be used. In Scotch practice fines are undesirable, while in many of the proposed retorts which contemplate stirring the shale in thin layers and putting it through in very short periods, fine grinding may be essential.

A series of experiments, in which oil-shale particles of various sizes were plunged into a lead bath at constant temperature, indicated that crushing finer than about $\frac{1}{4}$ in. caused no more rapid evolution of vapor.¹⁹ The whole problem needs closer consideration and determination in a way that will define the physical factors involved independently of any particular retort.

(b) Shall steam be used? If so, shall steaming be practiced in the same retort in which oil is produced,

¹⁹Unpublished work. The shale in these experiments was not stirred.

or shall the residue from retorting be treated in a separate chamber?

The answers to these questions must vary with the retort which is used. The Scotch retort in its present form operated without the use of steam would be an absurdity, while it is possible to design a retort which will produce just as good oils without the use of steam as with it.²⁸ Granting, then, freedom of choice in retort design, it would seem that the use or non-use of steam depends upon the cost of steam under the given conditions, the increased yield of ammonia obtained, and the difference in retorting cost caused by its use. The latter would require analysis for each new case, and would include difference in capital cost and operating cost on retorts, plus the additional expense caused by manufacturing a relatively large volume of water-gas, which must be handled, stored and burned, in place of burning the gas-forming constituents directly out of the spent shale. The determination of the magnitude of these various factors for different shales presents a large field for research.

The present state of our knowledge on the effect of steam and gases in ammonia recovery has been summarized by Franks.²⁹

RATE OF HEATING

(c) What is the proper rate of heating to employ? Is oil that is produced in a retorting time of 30 minutes or less as good as oil that is produced in 3 or 4 hours or more?

This problem has received some attention, and many conflicting opinions may be found in the literature, but the issues in connection with it have not been differentiated clearly. Objections offered to short retorting periods usually are based on inferiority in experimental short-time oil, due to the fact that it has been necessary, as a consequence of the design of the experimental retort, to employ high temperatures in order to secure short retorting times.

Again, the quality of the oil obtained depends upon time, temperature and pressure during its sojourn in the retort, so that an oil made in 3 hours with the use of large amounts of steam or gases to remove oil vapors from the retort may represent the same actual contact time at the retort temperature for the oil itself as a similar oil made without steam in about one-sixth the time.

These conditions are not always easy to determine; but it should be possible to settle this controversy satisfactorily by small-scale experiment, provided care is taken to define completely vapor contact times, refluxing effects and actual wall temperatures, as well as the retorting time. A simple comparison of oils made with short and long retorting times means absolutely nothing without these other data.

INFLUENCE OF SECONDARY DECOMPOSITION

(d) What is the influence of secondary decomposition? What is the maximum permissible temperature along the walls of a retort, and what is the effect of the time factor in this connection?

It has been accepted generally as axiomatic that the maximum yield of good oil is obtained by withdrawing all vapors as soon as possible without heating them

above the temperatures at which they are formed. There is a basis for this belief, but it is a half-truth.

By secondary decomposition is ordinarily meant avoidable cracking, which reduces the oil yield below the maximum obtainable. The exact point where primary pyrolysis of kerogen to form oil ceases and secondary decomposition begins never has been defined, but it might be well to accept the yield and quality of oil obtainable from a given shale under optimum conditions in a laboratory retort as the criterion, and assume that any reduction of this yield, due to overheating of vapors, is a measure of secondary decomposition.

Secondary decomposition, in this sense, is a chemical reaction and cannot be defined fully in terms of temperature. It must depend upon time, pressure and the presence or absence of catalysts as well.

It has been shown at the Mellon Institute that shale-oil vapors may be heated as much as 250 deg. C. above the temperatures at which they are formed, for short contact times of the order of 1 second, without suffering any marked change in yield, gravity or unsaturation. On the other hand, it is known that much milder overheating for longer periods of time decreases the yield; while, if samples of shale-oil are maintained at or even below the temperatures at which they were formed, in stills provided with refluxing condensers, they may be cracked to coke and gas within several hours.

It may never be possible to treat the reactions involved with the mathematical nicety of simpler ones; but a broad field for research is open, and it may some day be possible to predict the percentage of the theoretical yield which will be obtained in a proposed retort, from a knowledge of its volume, the rate of evolution of vapor, its wall temperature at all points, the magnitude of refluxing effects and the pressure and gas-tightness under given operating conditions.

TEMPERATURE AT END OF RUN

(e) What is the best "finish" temperature to use in the retort—i.e., how hot should the shale be heated before discharging?

The answer to this question will depend largely on whether steam is to be used or not.³⁰ If steam is used, "finish" temperatures should be sufficiently high to permit practically complete removal of fixed carbon from the spent shale by the steam, according to the water-gas reaction. The maximum temperature in Scotch practice is about 1,300 deg. F. Where steam is not used, the desirable "finish" temperature depends entirely upon the disposition of the spent shale. If this is to be burned, it would seem to be economical to carry the distillation no further than is required to recover all obtainable oil, since it is cheaper to burn a given amount of gas-forming constituents out of the spent shale than to distill the gas from them, handle it, store it in gas-holders, and then burn it. The spent shale as discharged is already hot and in ideal condition for immediate combustion. It appears that it can be burned easily under the proper conditions, but many problems remain to be considered adequately.

(f) What pressure should be used in the retort?

Mechanical limitations must influence the decision as to pressure. If ovens or retorts of ceramic material are used, it will be desirable to operate at very slight positive pressure, in order that the retorts may be self-

²⁸See Botkin, *CHEM. & MET. ENG.*, vol. 24 (1921), p. 876; and *U. S. Bureau of Mines Reports of Investigations*, No. 2254. For an exposition of the opposite view, see George, *Colorado Geological Survey Bull.* 25.

²⁹*CHEM. & MET. ENG.*, vol. 23 (1920), p. 1149.

³⁰The question of the use of steam has been considered in (b), pages 549 and 550.

sealing and any unnecessary oxidation of oil vapors may be avoided. Byproduct coke-oven practice is available for guidance in such cases.

On the other hand, where retorts are constructed of iron or alloys, more latitude in pressure may be enjoyed, and it may be desirable to operate under negative pressure, to assist in removing vapors quickly. Retorting under higher pressure yields a larger percentage of saturated oils, as has been reported by George.²⁵

While pressure cracking of oil-shale might present problems which could not be solved economically on a commercial scale, the influence of pressure on the character of the oils formed requires attention.

(g) What is the influence of the admission of air or combustion gases retaining some oxygen on the quality of the oils formed?

Certain inventors propose to pass the combustion gases through oil-shale, to assist in the retorting process; and while it is known that shale oils are very susceptible to oxidation, the exact effects of small percentages of oxygen in the retort atmosphere do not seem to have been determined. The practice of introducing a small amount of air in the Young and Beilby retort is an argument for the utility of the above procedure.

INFLUENCE OF VARIOUS ADDED MATERIALS

(h) What is the influence of adding various materials to the oil-shale during the retorting process?

The field for any modification of the retorting process such as is suggested by this question would be very limited indeed, in view of the large tonnage of low-grade material which must be handled and the fact that few possible materials are available at low enough cost which might have beneficial effects.

Gypsum has been mixed with shale before retorting, and the effect of the steam produced has been shown to be similar to the effect of the same amount of steam introduced from an external source.²⁶ Aluminum chloride²⁷ also has been mixed with shale before retorting; but it was shown that it sublimes into the condenser for the most part before oil is evolved from the shale, later polymerizing the vapors entering the condenser to a solid plug of bituminous material. It also has been proposed to introduce iron or iron salts in the retort to reduce the sulphur content of the oils.²⁸

The study of the action of various catalysts and reacting substances should give at least a new insight into the retorting process, if it is not productive of important commercial results.

CHOICE OF FUEL

(i) What fuel shall be used? What is the heat balance in the retorting operation?

The question of the sufficiency or insufficiency of fixed gases as retort fuel has been considered most fully by Gavin and Sharp,²⁹ who have made an excellent start in this field of inquiry.

(1) The results of researches such as the above should be extended to include a larger number of shales. However, much of this horizontal increase in our knowledge of oil-shale must await commercial development on a scale sufficient to pay for research.

(2) The effect of the "finish" temperature on the

gas yield has not been considered fully. For example, Gavin and Sharp²⁹ assume that the amount and calorific value of gas recovered at 482 deg. C. and at 925 deg. C. is the same, although they mention the fact that higher "finish" temperatures produce more gas. A clear distinction must be drawn in this connection between retorting temperatures and "finish" temperatures, since there is no necessary connection between the two.

(3) The heat of reaction involved in the formation of oil from kerogen is a figure essential for striking a proper heat balance, but there is much that is not known about it.

McKee and Lyder³⁰ have made an impressive beginning in the field by developing a calorimetric method for the direct determination of the heat of reaction. Their results, however, indicate a considerable endothermic reaction, while the investigation of Gavin and Sharp²⁹ shows a rather strong exothermic reaction. The discrepancy seems to indicate a field for further investigation inasmuch as both pieces of work are quite authentic.

2. AMMONIA RECOVERY PROBLEMS

The production of ammonia in the retort has been considered; and inasmuch as the manufacture of sulphate of ammonia *per se* is in effect a separate industry, having its own problems and its own equipment purchasable in the open market, it need not be discussed here. It is pertinent, however, to call attention to the profound influence which ammonia recovery may have on the solution of the retorting problem.

3. THE DISPOSAL OF SPENT SHALE

In the majority of cases, spent shale probably will prove to be valueless and will have to be dumped. In particular cases, however, it is entirely possible that the manufacture of byproducts from spent shale may rival the main business of manufacturing shale-oil. Among the possibilities suggested are the following:

(a) The recovery of potash.

The spent shale obtained from many shales contains a small percentage of potash, and in some cases this might be leached out at a profit. The problems presented should not be difficult to solve, but have not yet been met.

(b) Use direct as a fertilizer.

Used alone, the potash content of spent shale would scarcely be sufficient to class it as a fertilizer. It seems probable, however, that, in certain cases where the shale plants are located in agricultural districts and no freight charges must be met, the spent shale might be sold locally as a filler for compounded fertilizers, and might command a price based on its soluble potash content.

(c) Preparation of decolorizing "carbon" from spent shale.

While this field does not seem to offer promise, it must be admitted that its possibilities have not been explored to any extent.

(d) Recovery of precious metals.

This "problem" seems to give more trouble to the unwary investor than to the technologist, but "values" have been reported in some oil-shales, and it is not impossible, though unlikely, that in particu-

²⁵R. D. George, *Bull. 25*, Colorado Geological Survey, p. 65.

²⁶George, *Colorado Geological Survey Bull. 25*.

²⁷Unpublished work, Mellon Institute of Industrial Research.

²⁸G. E. Heyl, *British Pat. 115,452*, September, 1917.

²⁹State Colorado Co-operative Oil Shale Investigation, *Bull. 1*.

³⁰*J. Ind. Eng. Chem.*, vol. 13 (1921), pp. 678-84.

³¹*Loc. cit.*

lar instances commercial recovery may be carried out.

(e) Use as an insulating material.

Schmidt¹⁸ has advocated the use of spent Wurtemberg shale as a heat-insulating material. While such a use might have only local significance in this country, it should receive further consideration, if only as a possible source of insulating brick for use in shale works not near better raw material.

(f) Brick manufacture.

Thomas¹⁹ has discussed the use of spent shale in brick manufacture and reports that practical tests have shown that satisfactory brick can be made from spent Colorado shale.

The success of such a plan will depend almost entirely upon the nearness to the market, and it appears that, in the case of our richest Western deposits, the manufacture of any large quantity of heavy low-grade products of this sort will be out of the question. On the other hand, there are shale fields more favorably located where conditions are more promising. Only a very limited number of ash analyses have been made, and a broad field is open for further work.

(g) Manufacture of portland cement.

A process of retorting oil-shale has been proposed,²⁰ in which the spent shale is burned in a rotary cement kiln and in which the retort proper is heated by waste heat from the kiln.

The suggestion that portland cement be made from spent shale apparently has occurred to many, but little actually is known about the suitability of spent shales from various localities. The economic limitation imposed by transportation also seems likely to restrict this use to certain deposits.

4. THE DISPOSAL OF EXCESS GAS

No problem is presented in disposing of excess gas, since the communities which must be built up to operate shale works of any size can absorb any excess not used around the works.

It should be pointed out, however, that shale gases made without steam contain considerable percentages of olefines, the amount reaching 10 per cent in some cases. This should be sufficient to warrant the use of the gas as the basis of a chemical products industry at some future time. It is beyond the province of this paper to detail the possibilities, as the olefine-products industry forms a separate field.²¹

C. Refinery Problems

The problems of the petroleum industry²² are to a large extent also the problems of the shale-oil industry. However, problems such as the disposal of acid sludge take on a new significance where the amount produced exceeds 20 per cent of the volume of crude oil refined.

It will not be attempted here to deal with all the problems of shale-oil refining. Of course, the oil should be refined to recover products of maximum value, and in view of the wide variations among shale-oils, no general or sweeping statements can be made. Many problems can be handled ably by those experienced in petroleum refining.

On the other hand, there are certain fundamental

differences between shale-oils and petroleum oils which suggest problems not familiar to the refiner of petroleum. Some of these will be presented.

The most important problem before the prospective shale-oil refiner is the general one of refining a highly unsaturated oil economically. So far as the lighter fractions are concerned, the problem is similar to that of refining pressure distillates, and yet it possesses points of difference from the latter, in that the percentage of unsaturates found in shale-oil gasoline fractions probably averages higher than in the case of pyrolytic gasoline, and in that compounds are present in the light shale-oil distillates which are not found in ordinary pressure distillates.

The problem is met in the Scotch industry by using small quantities of acid and by resorting to several redistillations. The intention of the Scotch refiner is to use as much acid in treatment as is possible without attacking the olefines.²³

While Scotch practice might be followed on American shale-oils not requiring more drastic desulphurization, it appears that there is excellent chance for improvement in the procedure. The possibility of refining entirely by fullers earth,²⁴ bauxite, silica gel and various other adsorptive agents has occurred to many. It may be stated confidently that these and all other means of refining which avoid sulphuric acid treatment may look to shale-oils with more hope than to most petroleum refining, not because any proof has been advanced of their superiority, but because the need for some economical method of refining is greater, and because there is more room for improvement in the case of shale-oils. It is possible that the practice of refining oils with sulphuric acid may some day be abandoned.

In case sulphuric acid treatment is adhered to as the basis of the refining treatment, for the lighter fractions other problems must be met. The most important of these is, how far must refining be carried to produce a satisfactory product? Refining loss can be reduced considerably if odor and color are ignored, and a red product is marketed. It is not entirely clear whether such a red color would be an asset or a liability, but we do not yet know to what extent the color is produced by gum-depositing compounds whose presence to any extent in a shale motor-fuel or burning-oil would be objectionable. Refining must certainly be carried far enough to reduce the gummy polymerization or oxidation products within permissible limits. Does this necessitate the removal of the red color or not?

The question of whether lighter acid can be used to advantage has not been dealt with properly. What is the advantage of blending a crude shale-oil with petroleum before refining, if any? Could a cracking distillation be so regulated as to yield a higher percentage of desirable oils in the "once-run oil" from the nitrogenous tars in the crude shale-oil? Could these tars be separated from the oil, and separately treated or cracked to produce more valuable products?

RECOVERY OF LUBRICATING OILS

Coming to the lubricating oil fractions, and taking into account the variations which may be expected, certain fundamental peculiarities seem again to distinguish these from similar products obtained from petroleum. In general, shale-oils provide a source of only relatively low viscosity lubricants, containing con-

¹⁸Die Verwertung des Oelschiefers," Wittwer, Stuttgart, 1920.

¹⁹CHAM. & MET. ENG., vol. 24 (1921), p. 389.

²⁰R. W. Lesley, U. S. Pat. 1,323,294.

²¹See Curme, CHAM. & MET. ENG., vol. 25 (1921), pp. 907 seq.

²²On some of the problems of the petroleum industry, see, for example, Hamor, CHAM. & MET. ENG., vol. 23 (1920), p. 425.

²³Steuart, J. Soc. Chem. Ind., vol. 8 (1889), p. 100.

²⁴In this connection see U. S. Pat. 1,340,889.

siderable amounts of easily oxidizable material which must be removed.

Even though in the earlier stages of the shale-oil industry in this country no attempt may be made to recover lubricating oils, it must be realized that, although other substitutes may be found for motor fuel, it is probable that oil-shale and coal will be ultimately the only important sources of lubricants, unless some way is found of greatly cheapening vegetable or animal oils. Hence it is important that some means be developed for manufacturing economically as wide a range of lubricants as possible from shale-oils.⁴² Means have been found for increasing the viscosity of low temperature coal-tar fractions,⁴³ which have potential value for this purpose.

SHALE-OIL RESIDUES

Another set of problems will accompany the application of shale-oil residues to the common uses for petroleum residues, such as for roofing, paving and compounding with other asphalt products for various purposes. Practice in the Scotch industry has been to carry out a first and partly destructive distillation to coke. This treatment, logical enough in the case of the Scotch shale-oil, the most valuable product of which is paraffine, certainly will not fit all American shale-oils. Not very much is known of the properties of shale-oil asphalts,⁴⁴ although from their nature it is to be expected that they will prove intermediate in properties between petroleum residua on the one hand and coal-tar pitches on the other. Studies of air-blowing and sulphurization of shale-oil asphalts do not appear to have been made, but deserve attention. Owing to their nitrogen content, some peculiar properties may be found which will indicate special applications. Mention has been made of the presence in the crude shale-oil of tars soluble in 95 per cent ethyl alcohol.

MINOR BYPRODUCTS OF SHALE-OIL REFINING

In addition to the staple products mentioned above, a considerable number of specialties may be manufactured from shale-oil; and while these may never assume great commercial importance, they may form the basis of small branches of manufacture under especially favorable circumstances.

On account of their unsaturated nature and accompanying reactivity, shale-oils may possess potentialities not possessed by petroleum as a basis for the chemical manufacture of fatty acids, drying oils and other products. This field is quite untouched, since most of the possibilities of the better-known petroleum industry along this line have not yet unfolded.

Certain shale-oil fractions differ sufficiently in composition from the corresponding petroleum solvents to make it seem reasonable that their characteristic properties may command a market different from or even better than that open to petroleum solvents.

The preparation of various dyestuffs from shale-oils has been advocated by many persons, though mostly by typical promoters of the worst sort. However, it cannot be denied that this field is entirely open, and that it is by no means impossible that a variety of dyestuffs may some day be prepared from shale oils.

The possible preparation of polymerization resins

similar to coumarone resins from coal-tar distillates is another field so far unexplored.⁴⁵

Ichthyol,⁴⁶ a product manufactured from an Austrian fossiliferous shale, may be prepared from certain American bituminous minerals. However, it commands a relatively small market, and would not repay any great amount of effort.

Judged by present specifications, shale-oils are ill-adapted to furnish impregnating oils for timber. As these specifications are based upon properties desirable in coal-tar impregnating oils, however, it is quite possible that shale-oils should be judged by different standards. Their content of unsaturated hydrocarbons and nitrogen compounds distinguishes them from petroleum and coal tars for this purpose. The Forest Products Laboratory, at Madison, Wis., is obviously fitted to consider the problem.

The application of shale-oils to the froth flotation of low-grade ores has occurred to many workers; but while numerous tests have been made with them, they have not yet been applied commercially with success, to the writer's knowledge. Preliminary tests have not indicated that crude Colorado shale-oils show any marked superiority over crude petroleum under the conditions of experiment. At least one company⁴⁷ is said to be marketing shale-oils for flotation, however, and has advertised for sale a trade-marked brand of flotation oil manufactured from oil-shale. It is possible that, with the return of the copper industry to normal, a considerable field may be opened for the application of shale-oils to ore flotation.

Many other proposed byproducts have come in for attention, all of which present problems before anything commercially profitable can be developed from them. In the present state of the art, these can be listed only as suggestive of possibilities, for information is not available nor has the writer the specialized experience to catalog the problems which would be met in attempting their commercial application. Sheep dips, shale soaps⁴⁸ and insecticides⁴⁹ may be mentioned.

In almost all departments of the shale industry, many problems remain to be met, and in many cases the present knowledge is so fragmentary and proposed applications of this knowledge are so embryonic that one cannot even state intelligently the problems to be met. But that they will and must be solved cannot be doubted.

Potential Demand for Cosmetics in China

A potential demand for cheap grades of cosmetics in increasing quantities exists in China, says Consul General Cunningham in a report to the Department of Commerce. Native preparations are gradually giving way to imported articles. Highly perfumed toilet waters, face cream, powder and tooth paste are in demand.

⁴²For a review of the literature on coumarone resins from coal tars and their uses see *J. Ind. Eng. Chem.*, vol. 8 (1916), p. 797.

⁴³For general information on ichthyol see "Tariff Information Surveys," A-12, Par. 561, Washington, 1921. It should be noted in this connection that the Meadows Chemical Corporation, 52 Vanderbilt Ave., New York City, has placed on the market an ammonium ichthyolate obtained from an asphaltic limestone found near Burnet, Tex. United States Pat. 1,271,387 and 1,073,548, owned by the Atlantic Refining Co., cover the preparation of a similar ichthyol substitute from filtered lubricating distillates from petroleum.

⁴⁴Reference is had to the Muscle Shoals Oil Refineries (Ginet process), of Denver, Col., and "Mutual 100 Flotation Oil."

⁴⁵The Oil Shale Mining Co., of Hastings, Neb., has put on the market soaps which are said to contain shale-oils.

⁴⁶On the use of petroleum oils as insecticides, see *J. Econ. Entom.*, vol. 11 (1918), pp. 70 and 299. It would seem that shale-oils, by reason of their unsaturated hydrocarbons and their content of alkaloidal compounds, might be expected to compare favorably with insecticides from petroleum.

⁴⁷In this connection see Brownlee, U. S. Pat. 1,309,432.

⁴⁸Fischer, "Ges. Abhandl. zur Kenntnis der Kohle," vol. 1 (1917), p. 254.

⁴⁹Cf. Botkin, C. W., *CHEM. & MET. ENG.*, vol. 26, p. 398, March 1, 1922; p. 445, March 8, 1922.

"Science as Applied to Industry" at Yale*

BY WILLIAM E. FORD

Professor of Mineralogy in the Sheffield Scientific School,
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A NEW course of study known as "Science Applied to Industry" has this year been offered to the students in the Sheffield Scientific School for the first time. Since this new course has proved to be the most popular choice of the present Sophomore class in the Scientific School, it having been elected by almost one-quarter of the entire class, it should be of interest to examine somewhat in detail its contents and aim.

In the past, many graduates of the Sheffield Scientific School who had taken technical courses, such as those offered in the various fields of engineering or in chemistry, have become after graduation managers and executives in various lines of industry rather than the technical men for whom their undergraduate course was designed. These men desired in their college course a thorough knowledge of the scientific fundamentals of their work and a mental training in scientific methods of thinking, but they did not need all the details of technical knowledge that a professional engineer or chemist requires. It was for this class of men—always numerous but increasingly so in the last decade—that the course known as Administrative Engineering was established last year, to be followed this year by the course in Science as Applied to Industry. To quote from the description of the latter course in the Scientific School pamphlet, "This course is not designed for those students who are seeking preparation for a professional career in some particular branch of science, such as chemistry or metallurgy, where problems of production are likely to occupy his attention; such professional training can best be secured in other courses. The prospective professional chemist, to mention a single instance, requires a training different from the prospective business manager in a chemical-manufacturing plant. It is to supply the training necessary for men to function intelligently and efficiently in important executive and managerial positions in the business world, where a knowledge of science and of the scientific approach to business problems is indispensable, that this course has been provided."

PLAN OF THE CURRICULUM

In planning the curriculum of the course, naturally the first requirement was that it should include the elementary but indispensable courses in physics, chemistry and mathematics. Next, it was felt that no attempt should be made to cover the whole field of natural and physical science, but rather attention should be concentrated upon three branches of science—viz., chemistry, metallurgy and geology. The work in these sciences is so arranged that a natural and logical order of development is followed, covering, in some cases, 4 years of work in a single subject. A graduate of this course will therefore have acquired quite a comprehensive knowledge of these three scientific fields.

A business manager should be familiar with the characters and occurrences of the raw materials with which his business deals. The courses in mineralogy and geology cover this field for the mineral products while the course in zoology and botany which is offered as an option in Junior year will serve in a similar way

for the animal and vegetable products. Secondly, he should be familiar with the methods by which these raw materials are prepared for industrial use. The courses in chemistry and metallurgy will, at least in part, meet this requirement.

In addition to these scientific subjects, the course includes in Junior and Senior years a series of courses grouped under the general heads of Social Sciences and Business Administration. These latter courses are naturally of great interest to the prospective executive.

The various courses offered are:

Sophomore Year. The total number of hours per week, including the hours allowed for preparation, is 48. The number of hours assigned to each subject is indicated in parentheses after the name of the course.

Mathematics (9). Physics (12). Modern Language (9). English Composition (4). Qualitative Analysis (8). Mineralogy (6).

Junior Year. The total number of hours per week for Junior year is 45.5. Of these, 34.5 are required, and one of the two options offered will provide the remaining 9 hours.

Physical Chemistry (6). Physical and Historical Geology (6). Elementary Metallurgy (9). Drawing (3). Industrial Mineralogy (3). Economics and Business Finance (7.5). The two options are Elementary Botany and Biology (9). Modern Language (9).

Senior Year. In Senior year the total hours must number 45, of which 37.5 are required, while the balance is to be made up of choice from a group of elective courses.

General and Physical Chemistry (9). Economic Geology, Elementary Petrology and Applied Structural Geology (9). Industrial Management (6). Statistics and Reports (3.75). Metals and Alloys (3.75). Principles of Accounting and Cost Analysis (6). The electives include Elementary Organic Chemistry (9), Industrial Chemistry (8), Economic and Regional Geology (6), Business Law (3.75). Insurance (3.75). Metallurgy of Iron and Steel (1.5). Transportation (3.75). Economic Problems (3.75).

The recent reorganization of the university led the Corporation to constitute the Sheffield Scientific School the undergraduate school for "professional study in Science and Engineering," while Yale College is to be the school for "non-professional study in the Liberal Arts and Sciences." It was further provided that the courses of study offered in the Scientific School should have "the major portion of their total work in approved courses in the Physical, Mathematical and Natural Sciences," while for students in Yale College "the 'Humanities' should normally constitute the major portion of their total work." The course Science as Applied to Industry is the least technical of the courses now offered by the Scientific School, yet its subjects of study fall well within the established limits. The total number of hours required during the three years in the Scientific School is approximately 137, of which the minimum number of hours that must be devoted to the physical, mathematical and natural sciences would be 84, or over 61 per cent of the total. By varying the character of the electives chosen, this percentage could be considerably increased.

This course is naturally only in its initial stages, and will doubtless undergo numerous minor modifications which time and experience may show to be desirable. It seems to the writer, however, that the fundamental ideas of the course are thoroughly sound and that it should give to an increasingly large group of men information of value to them in their business lives, and, what is of greater importance, a training in accuracy of thought and precision of judgment that is most essential to success.

*Reprinted from the *Yale Alumni Weekly* of Dec. 16, 1921.

Contributions to the Study of Ammonia Catalysts—II

Description of Apparatus Developed by the Fixed Nitrogen Research Laboratory and Used in the Small-Scale Testing of Ammonia Catalysts at Variable Pressures*

BY A. T. LARSON AND A. P. BROOKS

IN ANY comprehensive study of ammonia catalysts it is essential to have available a relatively small simple apparatus capable of operating under variable pressures of at least 30 atmospheres and preferably up to 100 atmospheres. Such an apparatus should possess mechanical simplicity, ease of construction, alternation and repair and flexibility of control, and yet be capable of sufficient precision to assure results of reasonable accuracy.

An apparatus of this type affords a much more rigorous test of catalysts than is afforded by the still simpler tests at atmospheric pressure. It is admirably adapted to the study of the effect of pressure, temperature, space velocity and poisoning by water or carbon monoxide.

It is not so suitable for such studies as deterioration of catalysts over long periods of time as is a larger and more elaborate testing plant. Furthermore, it bears little relation to a commercial unit and is therefore unsuited for a study of such factors at temperature gradient within the catalyst, or heat recovery.

In August, 1918, the Geophysical Laboratory, working under a grant from the Nitrate Division, Ordnance Department, U. S. Army, began a study of the ammonia synthesis problem, and an apparatus of the type described above was designed by Adams, Franklin and Meldrum. At the end of a year this work was abandoned by the Geophysical Laboratory and the apparatus was transferred to the Fixed Nitrogen Research Laboratory. The apparatus described in the present article is a development of that set up by the Geophysical Laboratory, in which many of the original features have been retained and others modified or abandoned as experience has indicated.

In the main this report considers only the apparatus as at present employed, including, however, certain features not now in use, but which may perhaps be useful to others. It is not intended to be an exhaustive study of the entire problem and will therefore not consider other possible methods of achieving the same results.

OUTLINE OF COMPLETE APPARATUS

In order to clarify subsequent detailed discussion of individual items it seems desirable to outline at this point the apparatus as a whole, referring to Fig. 1 for illustration.

The crude nitrogen:hydrogen mixture issuing from the high-pressure line passes through appropriate valves into the purification system. Four cylinders of the gas mixture are floated in the line to balance pressure changes. The purification system consists of a bomb containing colloidal Al_2O_3 for preliminary removal of moisture, oil or other readily condensable vapors; a bomb

containing metallic copper at 400 deg. C. to serve as deoxidizer; a bomb containing a nickel catalyst at 275 deg. C. to hydrogenate carbon monoxide and other compounds; a series of three bombs containing Al_2O_3 to effect final removal of water vapor and other condensable gases.

From the purifying system the gas passes either directly to the catalyst bomb or to the humidifiers, according as dry or moist gas is to be tested. The humidifiers are essentially two small bombs containing water, the first at room temperature and the second maintained at a temperature designed to give the desired vapor pressure of water to the gas. Following the humidifiers is a trap, from which the gas passes directly to the catalyst bomb. From the catalyst bomb the gas passes through a valve, from which it issues at atmospheric pressure to the flowmeter and to the outlet tube from which samples for analysis are taken.

Copper tubing $\frac{1}{8}$ in. internal and $\frac{1}{4}$ in. external diameter is used to carry the gases. This tubing is connected through the walls of bombs and into valves, unions and tees by a standard device developed from the geophysical cone and gland and shown in Fig. 5. This consists of a steel tube $\frac{1}{2}$ in. in external diameter, terminating in a cone of $\frac{1}{4}$ in. diameter and a 59 deg. angle. Over the tube is fitted a steel gland, $\frac{1}{8}$ in. diameter, with $\frac{1}{4}$ -in. pitch to its thread and a $\frac{1}{2}$ -in. hexagon nut. By means of a steel sleeve the copper tubing is silver-soldered to the steel tube. This "cone and gland" is fitted into the shell of a bomb, or into a valve by cutting a standard gland and cone seat having a 60 deg. angle. By this device the bearing surface is reduced to a single line at the extreme inner edge of the cone tip. The torque required on the bushing nut to tighten the joint is very small and may be obtained by the use of a very small wrench or by hand. This type of connection is so frequently used and referred to that the above detailed description has seemed desirable.

SOURCES OF CRUDE NITROGEN:HYDROGEN MIXTURES FOR TESTING

Commercial cylinders of nitrogen and hydrogen under high pressures, provided with appropriate reducing valves and pressure flowmeters, may serve as the source of crude gas. The impurities in such gas, always considerable, and the attention needed for control of flowmeters render this method the least desirable.

A mixture of nitrogen and hydrogen gases in the ratio of 1:3 by volume may be obtained by decomposing ("cracking") ammonia, and if this is accomplished under pressure a self-contained apparatus becomes possible in which compressors are unnecessary. Such an apparatus, employing liquid ammonia as a source of both pressure and ammonia, has been developed by the Fixed Nitrogen Research Laboratory after designs originated

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*For Part I see CHEM. & MET. ENG., vol. 26, No. 11, p. 493, March 15, 1922.

by the Geophysical Laboratory and has operated successfully for pressures not above 30 atmospheres.

The method finally selected for obtaining nitrogen: hydrogen mixtures consists in using gas "cracked" at atmospheric pressure and compressed to about 1,500 lb. by the large-scale testing plant of the laboratory. The "cracker" used will be described in the third article of this series. This method allows wide pressure range and extreme simplicity of handling and is to be recommended whenever compression facilities are available.

Reduction of pressure from the high-pressure line to the pressure selected for operation was at first achieved by periodically charging a series of cylinders arranged in parallel, of such capacity that considerable amounts of gas might be drawn from them without substantial change in pressure.

Later this method was replaced by the use of commercial gas-reducing valves of sufficient capacity and range to deliver gas at the desired pressure in quantity sufficient for the operation of several bombs at once. The valve used for 30-atmosphere testing is a modified Cash standard reducing valve.

PRELIMINARY PURIFICATION

The importance of delivering to the catalyst bomb only gas of the highest possible purity or containing known amounts of definite impurities, as may be desired, can scarcely be overestimated. As mentioned in the preceding article, it is essential in a purifying system not only that it shall remove impurities present in the gas but also that it shall not introduce any impurities. The purification system herein described and indeed the apparatus as a whole is designed to achieve both of these results.

The gas received from the large-scale testing plant has already been subjected to purification, having been scrubbed with water, deoxidized and dried with alkaline

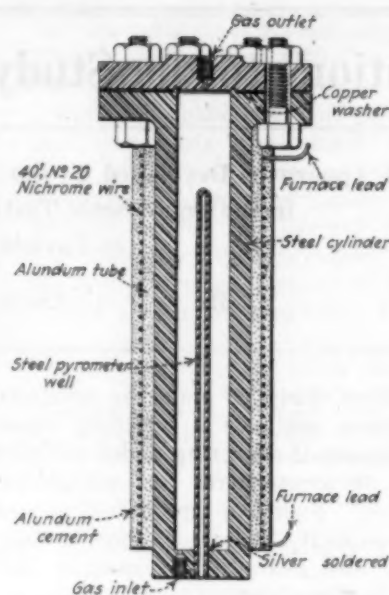


FIG. 2—DETAIL OF BOMB USED FOR COPPER DEOXIDIZER AND NICKEL CATALYST

driers. It is therefore free from ammonia and acidic constituents. It may, however, contain small amounts of carbon monoxide and in process of transfer to and from the storage cylinders it may acquire small amounts of moisture, oxygen and oil, from which it is almost impossible to free the steel cylinders. Preliminary purification of the gas is achieved by the use of a bomb containing granules of colloidal Al_2O_3 . This serves

to remove moisture, oil and other readily condensable vapors. The bomb is identical in construction and contents with those described later for the final drying. After this preliminary treatment the gas passes to the deoxidizer.

REMOVAL OF OXYGEN

Oxygen is removed by passing the gas over metallic copper heated to 400 deg. C. The final design of bomb for this purpose is shown in Fig. 2. It consists of a steel cylinder, 10 in. long, 2 in. external and 1½ in. internal diameter, closed at one end and widened at the other into a flange 4½ in. in diameter and ½ in. thick. A

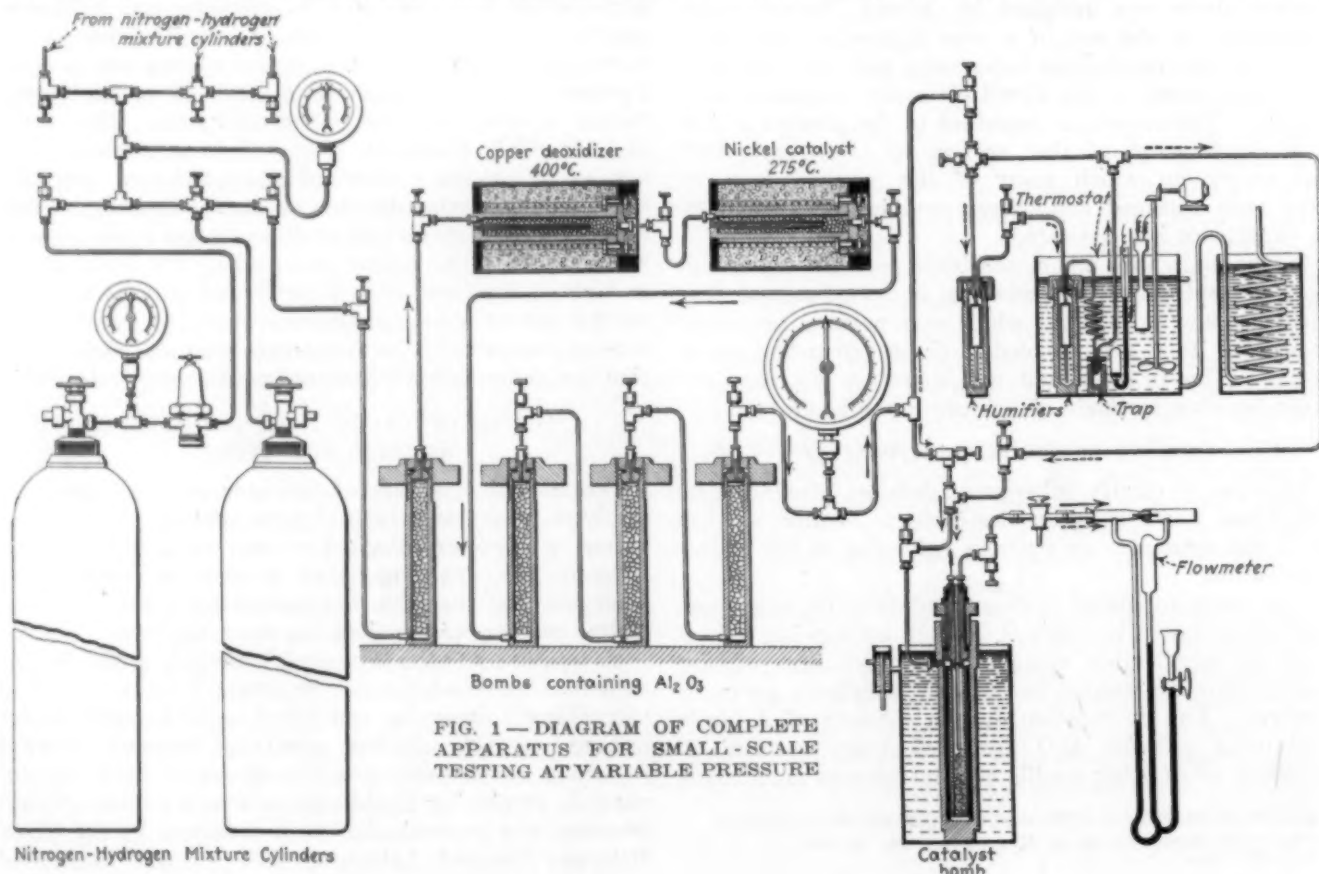


FIG. 1—DIAGRAM OF COMPLETE APPARATUS FOR SMALL-SCALE TESTING AT VARIABLE PRESSURE

head of the same diameter is fastened to the flange by seven $\frac{1}{2}$ -in. steel bolts. A copper washer fitting into an annular groove serves to make a gas-tight connection. The head is pierced in the center by a standard gland and cone seat as described above to serve as gas outlet. The other end of the bomb is pierced by a $\frac{1}{2}$ -in. hole into which is silver-soldered a heavy wall steel pyrometer well $8\frac{1}{2}$ in. long for temperature measurement. At one side of the pyrometer well a standard gland and cone seat is placed to serve as gas inlet. Over the steel bomb there is slipped an alundum tube wound with nichrome wire and packed with alundum cement, the whole fitting into a sheet-iron container. This bomb is charged with copper oxide, which is then reduced by the nitrogen:hydrogen mixture at as low a temperature as possible and is then ready for use as a deoxidizer.

HYDROGENATION OF CARBON MONOXIDE AND OTHER SUBSTANCES

It has been shown by Greenwood and Cowper¹ that small amounts of carbon monoxide are completely removed from hydrogen even at high space velocities by passing the mixture through a properly prepared nickel catalyst at 250 to 300 deg. C. The carbon monoxide is converted into methane, which is entirely inert toward ammonia catalysts. Other unsaturated bodies may be also hydrogenated and thus rendered more inert. In addition, the nickel may effect a marked rise in the boiling point of certain substances, thus rendering them more readily absorbable by Al_2O_3 . This point is discussed later.

The catalyst used in the present purifier follows Greenwood's specifications. It is prepared by impregnating nonpareil brick, crushed and screened to 4 to 8 mesh, with sufficient nickel nitrate solution so that on subsequent ignition and reduction the product contains 10 per cent reduced nickel. The material is dried at 150 deg. C., placed in a bomb identical with that described for the copper deoxidizer and reduced at as low a temperature as possible in a current of nitrogen:hydrogen gas. the temperature of operation is 280 deg. C. \pm 10 deg.

REMOVAL OF MOISTURE AND OTHER CONDENSIBLE VAPORS

Three bombs containing granular colloidal Al_2O_3 (Fig. 1) similar to that used for preliminary purification serve for the final removal of any readily condensible gases, particularly moisture. The method of preparation of colloidal Al_2O_3 was described in the previous article and will not be discussed here. It should be noted, however, that subsequent drying with P_2O_5 produces no change in the behavior of the catalyst, nor does scrubbing with liquid Na-K alloy, which was used in early experiments.

The bombs used to contain the Al_2O_3 were not specially designed for the purpose and therefore do not represent any features of particular interest. They have, however, been quite satisfactory. They consist of a steel shell, 12 in. long by 2 in. external and $1\frac{1}{2}$ in. internal diameter, fitted at the top with external standard pipe threads, $11\frac{1}{2}$ threads to the inch. The shell is drilled out at the top to $1\frac{1}{8}$ in. diameter, $\frac{1}{2}$ in. deep to form a seat for the lower face of the head. A steel head with a conical base fits into this seat, a soft copper gasket serving to make gas-tight connection between the two. The head is kept in place by a large steel nut,

fitting over the head and screwing over the end of the shell, a washer of Monel metal being placed between the head and the nut. The steel head is pierced by a standard gland and cone seat to serve as gas outlet and the bottom of the shell is pierced by a similar gland and cone seat to serve as gas inlet.

After passing through three of these Al_2O_3 bombs the gas is free from detectable moisture and is ready to enter the catalyst bombs for experiments on pure dry gas.

The effectiveness of the purifying train may be illustrated by a series of experiments carried out upon the gas at different stages of its purification. A coil of glass tubing was prepared through which the gas at any point in the line could be passed after reduction to atmospheric pressure by a valve. This coil was immersed in liquid air contained in a vacuum flask. On testing in this way the crude gas issuing directly from the high-pressure line at the rate of 500 c.c. per minute, an immediate cloudiness appeared in the upper part of the coil much above the liquid air, indicating the presence of considerable quantities of high-boiling liquid, probably largely water. There also appeared in a colder part of the coil just above the liquid air a condensate of very low-boiling material which evaporated very readily when the coil was removed from the liquid air, giving an odor characteristic of organic substances. On testing similarly the gas after passing the nickel catalyst, the low-boiling material had disappeared, leaving only a condensate of high-boiling material. Assuming that the low-boiling material consisted of hydrocarbons or their derivatives, the effect of the nickel catalyst had evidently been to convert them to substances having a boiling point of the order of that of water. On testing the gas after passing the aluminum oxide towers, no trace of condensate of any kind appeared for half an hour, when a faint cloudiness due to high-boiling material appeared. It is thus evident that a very complete removal of water or any other substance condensible by liquid air has been effected by the purifying system.

INTRODUCTION OF MOISTURE AND OTHER POISONS WHEN DESIRED

Since in any commercial plant it is almost certain that the gas used will contain small amounts of certain impurities, it is essential to be able to study the effect upon the behavior of the catalyst when definite amounts of impurities are introduced into the gas stream. The two chief impurities which will probably always be present in commercial gas are water vapor and (when water-gas hydrogen is used) carbon monoxide.

Water vapor is introduced into the system when desired by passing the gas issuing from the purification system through two humidifiers.

These consist essentially of small bombs of brass containing water through which the gas is bubbled. Brass is used instead of steel in order to avoid rusting and also because of ease of construction and rapidity of heat interchange. Their construction is shown in Fig. 3. They consist of a brass shell, $7\frac{1}{2}$ in. long by $1\frac{1}{2}$ in. external and $\frac{7}{8}$ in. internal diameter, fitted at the top with 1 in. of external pipe threads, 14 threads to the inch, to which the head is screwed. The head consists of two parts, a plug of Monel metal, as illustrated, pierced by two holes into which the inlet and outlet tubes, of $\frac{1}{2}$ in. copper tubing, are soldered. Over this plug the head, a hexagonal nut of brass, $2\frac{1}{2}$ in. diam-

¹Munitions Invention Department, Ammonia Synthesis, No. 12.

eter and $1\frac{1}{2}$ in. thick, is fitted, screwing over the top of the shell. The inlet tube terminates in a brass safety trap, designed to prevent water from accidentally sucking back into the system.

Following the second humidifier is a small brass trap of simple design (Fig. 3). It consists of a shell of brass 2 in. long by $1\frac{1}{2}$ in. external and $\frac{1}{2}$ in. internal diameter, fitted at the top with internal screw threads to hold the head, and at the bottom pierced by a hole into which is soldered a short drain of $\frac{1}{8}$ -in. copper tubing. This drain is closed by a soft solder plug to permit

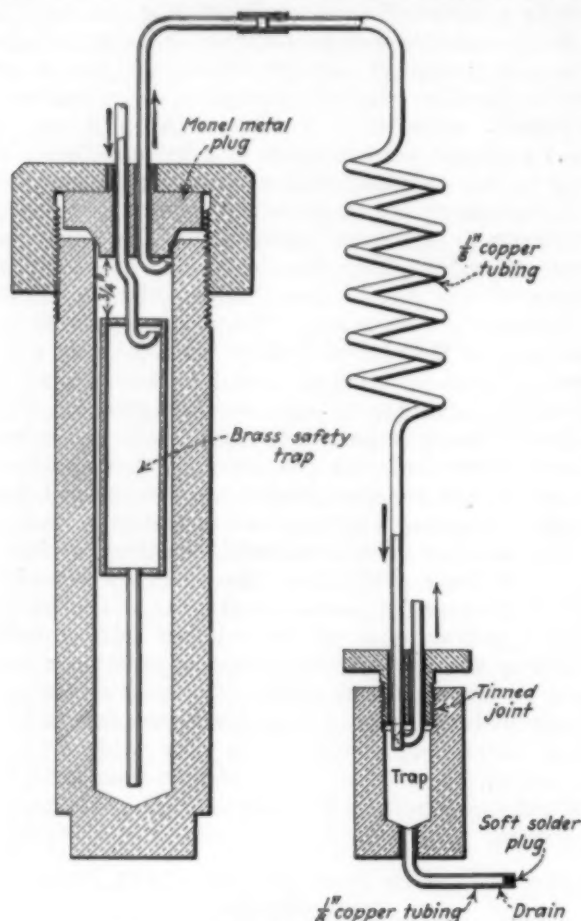


FIG. 3—HUMIDIFIER AND TRAP

drainage when desired. The head is a simple brass nut, pierced by two holes through which the inlet and outlet tubes of $\frac{1}{8}$ -in. copper tubing are soldered.

In practice, two of these humidifiers are used in series, the first one operating at room temperature and the other (with the trap) at a temperature controlled accurately by a thermostat at such a point as to give the desired degree of humidification. In this way saturation of the gas with water vapor at the desired temperature is achieved from the supersaturation side rather than the unsaturation side, a method which is shown to give more uniform results.

The gas issuing from the purification system passes through a tee valve, either directly to a manifold line leading to the catalyst bombs or through the humidifiers to a separate manifold. It is thus possible to operate one catalyst on dry gas while another is being operated on moist gas and at the same time to avoid contaminating the entire system with water vapor.

Carbon monoxide is usually introduced into the gas when desired at the large-scale testing plant where it is mixed with the nitrogen and hydrogen prior to com-

pression. It may also be introduced into the storage cylinders at low pressure before filling them with the nitrogen: hydrogen mixture from the high-pressure line. When testing gas poisoned with carbon monoxide the nickel catalyst is, of course, not operated.

DESCRIPTION OF THE CATALYST BOMB

The catalyst bomb is the most elaborate single unit of the complete apparatus and one which represents some of the greatest difficulties of construction. Its design is essentially based upon that of the bomb developed at the Geophysical Laboratory by L. H. Adams. A detailed sketch of the modified bomb is shown in Fig. 4 and should be used in following the description.

The shell is of steel, $15\frac{1}{2}$ in. long by $2\frac{1}{2}$ in. external and $1\frac{1}{2}$ in. internal diameter, enlarged at the head to $2\frac{1}{2}$ in. external and $2\frac{1}{2}$ in. internal diameter, and fitted at the head with internal screw threads, nine threads to the inch. Just below the screw threads several seats

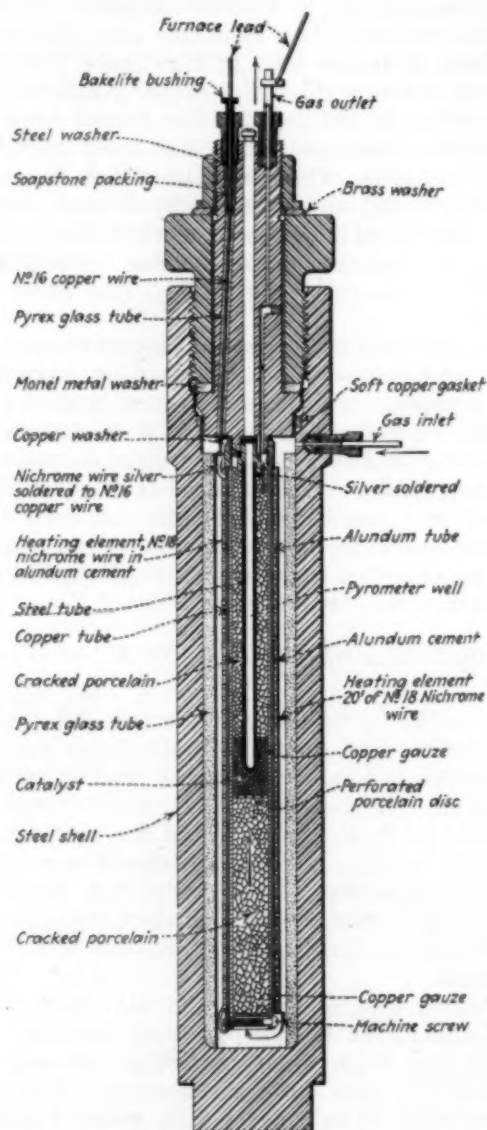


FIG. 4—CROSS-SECTION OF CATALYST BOMB

are provided, as illustrated, to fit the head and various washers, and just below these seats the side is tapped by a standard gland and cone seat to serve as gas inlet.

The head, itself of two distinct units, contains the pyrometer well, the gas outlet (a standard gland and cone seat) and the lead wire for the internal heating

element. The two parts of the head are fitted to each other by an upper washer of brass and a lower one of Monel metal. Gas-tight connection between the shell and the head is effected by the use of a gasket of soft annealed copper. It should be noted that only at this gasket is there a connection between head and shell which is subject to the stream of high-pressure gas.

One of the heating leads is connected directly to the head; the other is insulated from the head by passing through a Bakelite bushing into a conical soapstone plug, held in place by a steel washer. This type of high-pressure insulation has proved quite satisfactory. A Pyrex tube protects the lead wire from contact with the head after passing the soapstone plug, until it reaches the heating element to which it is silver-soldered.

The copper catalyst tube, 10½ in. long by ¾ in. external and 0.642 in. internal diameter, is open at both ends and is silver-soldered to a steel sleeve which screws into the lower end of the head.

Surrounding the copper tube is a thin alundum tube on which is wound the heating element, 20 ft. of No. 18 nichrome wire, imbedded in alundum cement. The winding is so designed as to give as little temperature gradient as possible within that portion of the tube containing the catalyst. A Pyrex tube, fitting closely the interior of the steel shell, serves to protect the steel from the hot gases and lessen the heat transfer to the walls of the shell.

OPERATION OF CATALYST BOMB

The operation of the bomb will be briefly described. The catalyst tube is filled by unscrewing the head with catalyst tube attached, reversing it and filling the tube half full of broken porcelain. Upon this is placed a copper gauze and upon this the layer of catalyst, about 1 in. in depth, so adjusted that the end of the pyrometer well is near its center. A perforated porcelain disk covers the catalyst and the tube is then completely filled with more broken porcelain, kept in place finally with a copper gauze, which in turn is held in place by a bolt to which the lower end of the heating element is attached. After being filled the head is then turned right side up and screwed into the shell.

The gas entering through the side of the shell above the catalyst tube passes down between the heating element and the outer Pyrex tube, thus becoming preheated, then upward through the catalyst tube and through the outlet in the head.

This bomb may be operated at any pressure up to 100 atmospheres and is capable of rapid temperature variation when desired. In order to permit the rapid temperature change the bomb is immersed in hot water, which, although causing a larger current consumption, permits greater

rapidity of reaching temperature equilibrium than would be the case if the bomb were packed in heat-insulating material. The water also serves to diminish the temperature of the head, thus avoiding damage to the insulating device and sticking of the screw threads.

It should be noted that when first constructed such a bomb (as the case of all other steel apparatus) is apt to contain considerable amounts of oil, soaked into the steel. This can best be removed by heating the bomb at about 600 deg. C. for several days in a current of pure gas until there is no longer evidence that oil is being carried through.

CONTROL AND MEASUREMENT OF GAS FLOW

The gas issuing from the high-pressure line passes through a commercial diaphragm reducing valve to a series of cylinders simply serving to balance the system against sudden changes of pressure. From this time on its control is achieved by the use of a number of small steel valves, whose design is shown in Fig. 5. These valves are connected into the pipe line, by means of the standard gland and cone seat, between all items of the system, and also serve for bypasses where desired. One of them releases the pressure after the gas passes the catalyst bomb.

Fig. 5 is almost self-explanatory, but it should be pointed out that the cone of the stem has a 30 deg. angle; that the stem packing of asbestos, previously slightly lubricated with paraffine and placed between cupped steel washers, has proved satisfactory; and that it is an advantage to make the diameter of the stem equal to that of the root of the screw thread—namely, ¼ inch.

The measurement of gas flow is effected after reduction of pressure by a glass flowmeter of standard type, xylene being used as measuring liquid in the arms. These meters are calibrated by stopwatch and water displacement.

CONTROL AND MEASUREMENT OF PRESSURE

Pressure in the system is controlled by the reducing valve previously mentioned. It may be noted that in a self-contained apparatus utilizing liquid NH_3 as a source of both gas and pressure, the pressure is determined by the temperature at which the ammonia cylinder is kept.

Pressure is measured on 8½-in. American standard hydraulic gages, graduated in 5-lb. divisions. All gages are of the usual Bourdon copper tube type. They are carefully calibrated from time to time against a hydraulic apparatus, using known weights as pressure standards.

CONTROL AND MEASUREMENT OF TEMPERATURE

Temperature control is needed (1) in the copper deoxidizer, (2) in the nickel catalyst, (3) in the second humidifier and (4) in the catalyst bomb.

With the exception of the humidifier, which is immersed in a water thermostat of appropriate size, the heating is effected in all of these cases by the use of nichrome heating elements, operating on the 110-volt circuit in series with rheostats. The rheostats are made in very fine steps, permitting continuous variation of temperature over a considerable range. No automatic control of temperature is attempted.

Temperature measurement is effected by chromel-

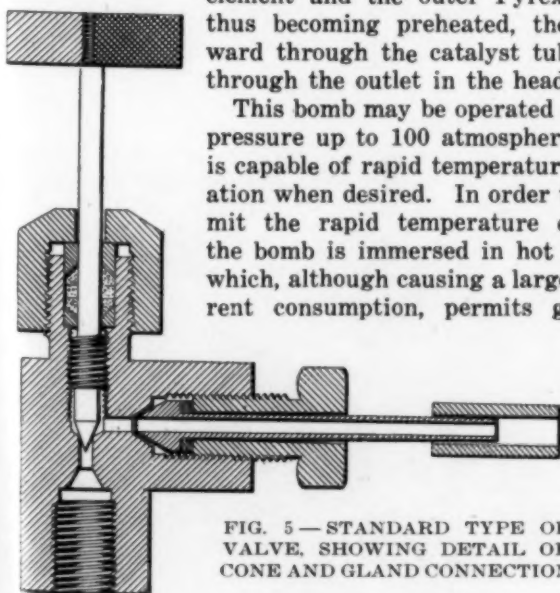


FIG. 5—STANDARD TYPE OF VALVE, SHOWING DETAIL OF CONE AND GLAND CONNECTION

alumel thermocouples leading into the pyrometer wells, the cold junction being maintained in a vacuum flask filled with crushed ice.

The temperatures are read by means of a White double potentiometer, manufactured by Leeds & Northrup and permitting the estimation of temperature to within $\frac{1}{2}$ deg. C. over the entire range of 200 to 700 deg. C.

It is most important in a critical study of ammonia catalysts that the temperature of the catalyst mass should be as uniform as possible and that the recorded temperatures should correspond exactly to those existing in the catalyst. The method of winding the heating element and the high thermal conductivity of the copper catalyst tube and steel pyrometer well contribute to achieving the former result; the latter is effected by careful calibration of all thermocouples every 2 weeks, against boiling sulphur. It is believed that the recorded temperatures do not vary from those actually existing in the catalyst mass by more than 2 to 3 deg. C.

ANALYTICAL CONTROL

Since the effectiveness of the catalyst is measured by the ratio of ammonia to nitrogen:hydrogen in the outlet gases, this represents the only necessary analytical determination. The method of analysis finally adopted is to pass the gas issuing from the catalyst bomb, after being reduced to atmospheric pressure, through a 4 per cent solution of boric acid, to absorb ammonia, and then into a compensometer³ by means of which the volume of the nitrogen:hydrogen mixture can be rapidly and conveniently measured. The boric acid solution is then titrated directly with standard H_2SO_4 , using methyl orange as indicator, and titrating to a definite color standard as end point. Experiments show that absorption of ammonia from the gas stream by boric acid is extremely rapid and complete and the method permits the use of only a single standard solution.

CONCLUSION

The apparatus herein described has been used for testing ammonia catalysts under varying conditions of pressure, temperature, space velocity and purity of gas. The results of these investigations will be discussed in the fourth article of this series.

(The third article of this series, describing a moderate-scale apparatus for testing ammonia catalysts at 100 atmospheres pressure, will appear in a subsequent issue.)

Coal Available in Case of Strike

An analysis of the coal situation, the purpose of which is to give business men information regarding possible fuel supplies in the event of a strike of miners on April 1, has been issued by the Coal Bureau of the Natural Resources Department of the Chamber of Commerce of the United States. The bulletin carries charts covering conditions in particular localities.

As the anthracite field is 100 per cent unionized, all supplies in the event of a complete closing of the mines will have to be drawn from stocks on hand. Reliable figures on which to base an estimate covering possible anthracite supplies in the event of a strike completely closing the mines are not available.

Assuming this year's bituminous consumption to be comparable to that of 1921, 7,600,000 tons per week, the supply from non-union fields would fall short 3,600,000 tons per week of meeting the demand.

³See CHEM. & MET. ENG., vol. 23, No. 23, Dec. 8, 1920, p. 1104.

A Paddlewheel Fan Adapted for the Removal of Suspended Particles

A modification in the design of the ordinary paddlewheel type of fan blower, whereby it is adapted for the removal of cinders and dust from the air it handles, has been developed by the B. F. Sturtevant Co. Buckets are provided at the inlet edges of the blades as shown in Fig. 1. From each bucket an inclined channel leads the



FIG. 1—ROTOR OF FAN, SHOWING COLLECTING BUCKETS AND CHANNELS

dust to a special dust chamber, where it drops out of suspension and is removed from hoppers periodically.

It is claimed that this type of blower is just as efficient as a fan as the average induced draft fan and that it removes up to 75 per cent of the solid matter in the air, depending, of course, on the nature of the material. Two large fans installed in connection with six 500-hp. boilers in New York City each remove about 250 lb. of cinders per hour when the boilers are operating at 20 per cent of rating. This type of fan has also found successful application in connection with boilers using pulverized fuel and should be useful in the chemical and metallurgical industries where the removal of suspended matter from gases is desirable.

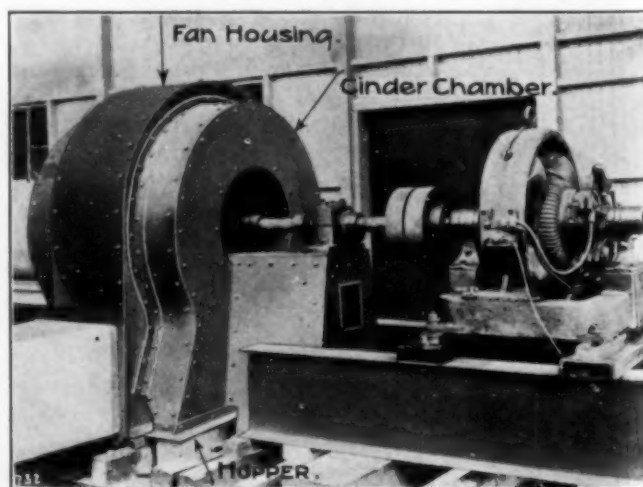
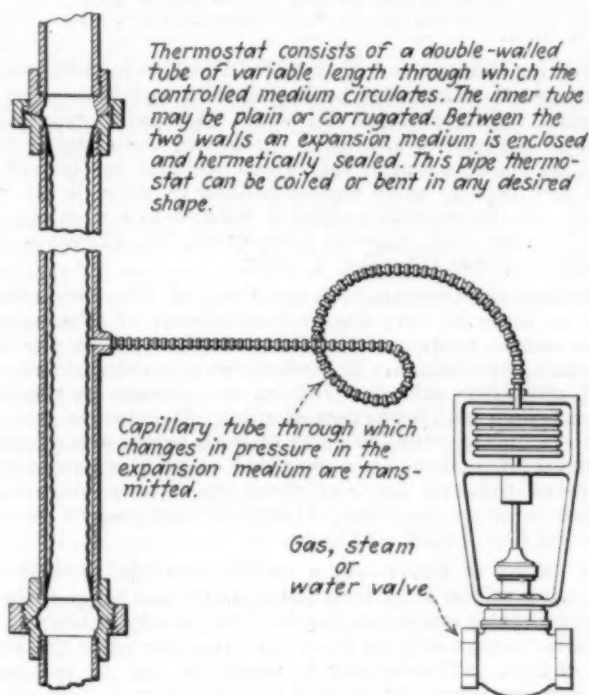


FIG. 2—ASSEMBLED FAN, SHOWING CINDER CHAMBER AND HOPPER

A New Temperature Regulator

Most of the temperature regulators on the market at the present time use tubular thermostats similar to the bulb of a distance thermometer. This tubular thermostat is commonly inserted in the heater, tank or receptacle the temperature of which is controlled. It frequently happens, however, that there is no room for the thermostat in this location and it is necessary to insert it in an outside pipe or a special chamber. This has certain obvious disadvantages. For instance, it involves extra expense in installation and the pipe or chamber tends to form a pocket, hindering the flow of the liquid, which in turn may result in irregularity of control.

A consideration of the problem involved and the existing methods has suggested the use of a pipe thermostat of the type shown in the accompanying illustration. This thermostat, which was recently developed



and patented by H. J. C. Wells of the Sarco Co., Inc., consists of a two-wall pipe in which the expansion medium, whether a sensitive oil or a volatile fluid, such as ether, is located between the two walls. In this construction not only is the controlled liquid allowed a free passage but the sensitiveness of the regulator can be greatly increased. This latter point will be appreciated if one takes into account that an ordinary thermostat tube or bulb has a certain definite proportion of heat-interchanging surface for a given content of the expansion medium it contains. On the other hand, with a pipe thermostat it is feasible to extend the length of the pipe considerably and its two walls can be so close together as to take between them little more than a film of liquid or a layer of gas; thus the ratio of heat-interchanging surface and volume of expansion medium is increased almost indefinitely. This results in nearly instantaneous heat interchange and reaction. The lengthening of the pipe thermostat involves no particular constructional difficulties, as it can be coiled, bent or otherwise deformed and in fact may constitute a part of the regular conduit used to convey the medium controlled.

Many applications for such a thermostat suggest themselves. For instance, certain heaters for liquids can be equipped with a pipe thermostat simply by substituting it for the exit pipe. Another application is in connection with the temperature control of the cooling water systems of air compressors and of gas and oil engines. The pipe thermostat takes the place of the discharge pipe and occupies practically the same space as the pipe now used. With gas-fired boilers, the pipe thermostat would be placed in the return circulation pipe and directly control the gas supply. In pasteurizers for milk, cider and other fruit juices, which are heated while in circulation, the pipe thermostat is preferable, because of its greater sensitivity and the ease with which it can be cleaned. The construction of the thermostat in the form of an open pipe may have other advantages, where the temperature of corrosive gas or liquids is controlled, since the inner wall can be of some acid-resisting material and the use of internal joints and solder entirely avoided.

Without impairing the useful field of the tubular thermostat for ordinary tank control, the pipe thermostat appears to offer decided advantages in these special applications.

Synopsis of Recent Chemical & Metallurgical Literature

Developments in Refrigeration.—In a paper on this subject read before the Glasgow Section of the Society of Chemical Industry by Dr. W. R. Ormandy and E. C. Craven and printed in *Chemical Age*, of London, on Feb. 4, 1922, the authors pointed out the disadvantages of the ammonia absorption system of refrigeration using water as an absorbing medium and suggested the use of solid ammonium nitrate for absorbing the ammonia gas.

When ammonia gas is passed over cooled ammonium nitrate, a liquid is formed possessing at ordinary temperatures the composition $2\text{NH}_4\text{NO}_3\cdot\text{NH}_3$ and freezing at 22 deg. C. At lower temperatures a compound $\text{NH}_4\text{NO}_3\cdot\text{NH}_3$ appears to be formed.

It was found under certain conditions the ammonium nitrate was changed into a cellular state, in which the full vapor pressure of the liquid compound was not exerted. To overcome this difficulty the liquid compound was absorbed in kieselguhr in such proportions that a dry powder was formed, reducing this possibility to a minimum.

In application to practice the authors state that against back pressures up to 190 lb. per sq.in. absolute all the ammonia-ammonium nitrate bodies containing over 6 per cent of ammonia were decomposed at a temperature of 230 deg. F., and that it required so much heat to drive off the remainder of the ammonia gas as to be uneconomical. At 144 lb. per sq.in. absolute back pressure all the bodies over 6 per cent NH_3 were decomposed below the boiling point of water. A stationary plant without agitation would work with ammonium nitrate-kieselguhr in the ratio 3 to 2 by weight, provided the cooling arrangements in the generator for the absorption period were adequate. There was no difficulty during generation with the absorbent present.

Determination of Oxygen in Hydrogen.—Alfred T. Larson and Ernest C. White of the Fixed Nitrogen Laboratory at Washington have made a valuable contribution to the operation of the Haber process by publishing a simple and rapid method for determining traces of oxygen in hydrogen. The paper appears in the January, 1922, number of the *Journal of the American Chemical Society* (vol. 44, No. 1, p. 20). One method has been to estimate the oxygen content by passing the gases over a contact mass which converts the

oxygen into water; the water being collected in an absorbent, usually phosphorus pentoxide, and then weighed. It is desirable to determine the presence of oxygen down to 0.001 per cent, and at this dilution it requires no less than 62 liters of the gas to produce 1 mg. of water. Because of the difficulties involved in the weighing of such small quantities of water, the method is both slow and inaccurate. Another method depends on the conversion of colorless cuprous solutions into blue cupric solutions by the presence of oxygen. The intensity of the color change becomes the measure of the oxygen content, but it lacks accuracy in low concentrations.

The new method is rapid and accurate for concentrations down to 0.001 per cent, and it is based in principle on the method of Lamb and Larson in determining low concentrations of carbon monoxide in air. In the new method, the trace of contained oxygen is catalyzed by platinum with the excess of hydrogen at a temperature of 275 to 300 deg. C. The temperature rise due to the exothermic reaction is measured by a copper-constantan thermocouple and a sensitive potentiometer. The apparatus must be calibrated by the use of gas mixtures of known concentrations, but this proves to be a very simple matter, the potentiometer deflection being plotted against the oxygen content, making possible results accurate to 0.00003 per cent of oxygen. Full details of construction and manipulation of the apparatus are given.

Brinell Hardness of Cementite.—The Brinell hardness of cementite is not known, according to Messrs. Portevin and Bernard in a paper entitled "Contributions to the Study of Coalescence in Steels and Its Commercial Results" before the Paris meeting of the British Iron and Steel Institute. It is not even possible to ascertain it directly by any of the usual methods on account of its extreme brittleness. The investigation, however, of the products of coalescence furnish the following methods of ascertaining it indirectly by extrapolation:

It is known that the hardness of binary alloys formed of a mixture of two similar constituents in variable proportions is practically a linear function of the composition when the structural elements remain constant in size. Furthermore, if the proportions of the constituents remain constant, the hardness will tend to increase as the fineness of the structural elements.

Iron-carbon alloys in the annealed state consist of two

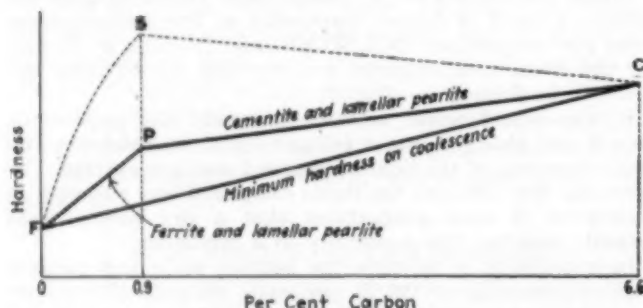


FIG. 1—BRINELL HARDNESS OF IRON-CARBON ALLOYS

phases, Fe_c and Fe_3C , intermingled, but the structural elements of which these elements are composed vary considerably in size according as they do or do not form part of the eutectic pearlite in its lamellar form. This lamellar pearlite forms a definite aggregate with 0.9 per cent of carbon and a Brinell hardness in the neighborhood of 250.

According to the rule just enunciated the Brinell hardness of iron-carbon alloys, starting with pure iron and going up to 6.60 per cent of cementite in the annealed state, can be represented as in Fig. 1. Thus: For the products containing pearlite in the lamellar state, by two straight lines, FP and PC , connecting the points indicative of the hardness of pure iron (F), of lamellar pearlite (P), and of the cementite (C). For the coalesced products in such a manner as to connect all the cementite elements in globular form, and of the same order of size, by a straight line of minimum hardness, FC . And lastly, for the products containing the whole of their carbon in the sorbitic state by an ill-defined

curve, FSC , relating to the maximum hardness in the annealed state.

It is practicable to plot points on the line FC , the minimum hardness of various steels and cast irons, a value which may be estimated by studying the degree of spheroidization of the cementite. Thus, whereas a piece of 1 per cent carbon-steel exhibiting lamellar pearlite, had a Brinell hardness of 262, after proper spheroidizing or coalescing, it dropped to 137. Accepting the hardness of ferrite as 75 (according to Howe) the Brinell hardness of cementite becomes about 400.

Recent Chemical & Metallurgical Patents

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Heating Practice.—Arthur E. Bellis, of Springfield, Mass., recommends that metal be heated in a salt bath prior to forging, rolling or other hot work. Accurate temperature control is possible, and when withdrawn the metal is covered with a thin film of salt which prevents surface oxidation and helps to avoid uneven chilling by variable air currents. In this manner scaling is reduced to a great extent and trouble and expense consequent to oxidation are avoided. (1,399,044. Dec. 6, 1921.)

Method of Alloying.—Aladar Pacz, of Cleveland, Ohio, uses an intimate, very fine-grained mixture of alloying element and an oxide acidic to it to introduce the former into an alloy. For instance, he precipitates a mixture of tungstic acid and silicic acid, and reduces the mixture to tungsten impregnated with 2 per cent of silica. Twenty-one parts of this are melted with 150 parts of steel having the requisite amounts of carbon, chromium and other elements except tungsten required for high-speed steel, to produce tools having superior qualities. (1,402,088; assigned to General Electric Co. Jan. 3, 1922.)

De-inking of Paper.—In a recently patented method for removing printer's ink from paper, the waste paper (printed newspapers) is macerated in an ordinary beater or is shredded by other means and the stock then transferred to the beating engine. After heating to about 140 deg. F. and made up to a consistency of about 6 per cent, enough soda ash or other alkali is added to give the whole a decided alkalinity. After beating for a short time, say from 10 minutes to half an hour, sufficient ordinary laundry soap is added to form a saturated solution and the beating is continued until the oil of the ink is thoroughly emulsified.

At this stage sufficient cold water is added to bring the consistency down to about 3 per cent and to reduce the temperature to 100 deg. F. The effect of adding the cold water is not only to thin down the stock but also to throw more or less of the soap out of solution, with the result that as the agitation or beating continues, the emulsified soap, oil and pigment will rise to the top in the form of dark soapy bubbles. These may be removed from the surface of the stock as it flows around the beater by any convenient means, as for example by rotary washing screens but preferably by a rotary skimming mechanism devised by the patentees. This mechanism consists of a wooden roller 14 so arranged that its under side just touches or is but slightly above the surface of the stock. In front of the skimming roller are two inclined deflectors 16, 17, extending under the roller as indicated in the accompanying figure, for the purpose of concentrating the bubbles toward the center of the roller. Beyond the roller is a dam 18 extending transversely across the channel between the midfeather and the side wall, and preferably inclined, with its upper edge close to the roller 14. The dam extends down a short distance into the stock, so that its effect will be to cause the stock itself to flow down and under the dam, while the bubbles, trapped by the dam,

Technical News of the Week

Current Events in the Chemical, Metallurgical and Allied Industrial Fields—Legislative Developments—Activities of Government Bureaus, Technical Societies and Trade Associations

Vindication of Dye Industry Seems Imminent as King Charges Prove Blind Leads

As the dye investigation stretches into its fourth week it is becoming increasingly evident that the domestic dye industry will be given a clean bill of health. Chief interest now is centered in whether or not the committee will insist upon information as to the real source of the charges made.

Irene du Pont expressed the belief, while testifying under oath before the Senate committee, that these charges had their origin in the German Cartel. To illustrate his point he cited a happening in the nursery of his home. Mrs. du Pont came into the room to find that the canary's cage had been thrown over and the bird badly mangled. She did not suspect the children. Her only thought was that the cat was responsible. Mr. du Pont suggested that the committee in this investigation examine the mouth of the cat and see if there are not some yellow feathers sticking to it. He emphasized the fact that the German Cartel must have an agent in this country, but he has not appeared before the committee and no one knows where he is. "I do not accuse Senator King," said Mr. du Pont, "because I think he believes honestly that the charges he makes are true." He emphasized, however, the necessity of ascertaining the source of Senator King's information. He asked why there should be any mystery about the quotations presented from out of the way newspapers. He told the committee that they should find out who furnished the material for those articles and who sent them to Senator King.

The consensus in Washington is that the domestic dye manufacturers have made a very convincing presentation of their side of the case. Despite the limited time to refute charges made by Senator King, there is indisputable evidence that the case against them is superficial to a degree that reflects very unfavorably upon Senator King and the unnamed persons who are holding up his hands.

HERTY ANSWERS KING'S CHARGES

Monday, March 13, was occupied by the testimony of Charles H. Herty, president of the Synthetic Organic Chemical Manufacturers' Association of the United States. Dr. Herty gave the committee a detailed account of his activities to obtain protection and development for the American organic chemical industry, which he declared is a matter of national necessity. Replying to the assertion by Senator King that the American Chemical Society, of which Dr. Herty was formerly president, was drawn into the campaign for protection for the industry by the Textile Alliance and the American Dyes Institute, Dr. Herty explained that the charge was ambiguous. The latter organization did not exist and the former was not interested in the distribution of dyestuffs when the American Chemical Society began its work for the development of the American industry.

Dr. Herty announced that he has never been a member of the American Dyes Institute and has no connection with the Chemical Foundation, although he is thoroughly sympathetic with its work. Moreover, King's charges that he is a member of the dye advisory committee of the Treasury Department is ridiculous in view of the fact that no such committee exists. The witness told in much detail of his trip to Paris in 1919 before the peace treaty was signed in order to obtain for American consumers necessary German dyes. He represented the State Department and his expenses were paid by the Chemical Foundation.

Dr. Herty added his corroboration to previous statements that there is no combination of any kind and no monopoly

in the American industry. He expressed the belief that the embargo offered the only adequate means of protection and that the fear that a monopoly would be created by the embargo could be removed by giving the President power to remove it if any product should become controlled by a monopoly or if American industry failed to manufacture at least 60 per cent of the products needed in the United States. Given proper protection, he concluded, the American manufacturer can produce quantity enough for the American consumer and the American quality is and will be at least equal to that of competitive products.

DYE BUSINESS NO BED OF ROSES FOR DU PONTS

Irene du Pont, president of E. I. du Pont de Nemours & Co., declared that he sometimes thinks he is "a damned fool" to remain in the dye business in the United States, for the business as he has found it is without profits and the target of constant attack. His company has lost money in dyes during the last 3 years, but he was impelled to hold on because of the great benefits it would accrue to posterity should the American industry have the chance of proper development.

Taking up the ramifications of the business interests of the du Pont company, Mr. du Pont asserted that the size of a company does not make it a monopoly. The parent du Pont Co. is large, but does not have a monopoly on any of the products in which it is interested, he stated.

"There has never been anything nefarious about our operations," said Mr. du Pont. "There has been no agreement, written or unwritten, no gentlemen's agreement or agreement of any other kind to establish a monopoly or to restrain trade. There is no such animal. The only monopoly I know of in the dye industry is the German I. G., the German dye monopoly."

SHORTRIDGE FAVORABLY IMPRESSED BY MANUFACTURERS' PLEAS

During an informal discussion following Mr. du Pont's testimony Senator Shortridge declared himself in favor of adequate permanent protection of the American dye and organic chemical industry, "by an embargo, if necessary." "I think I may say that from the evidence so far gathered, the present or temporary embargo seems to have worked very well," he added.

It might well be, Senator Shortridge said, that the American dye industry, "a unique industry," needs special, even unusual protection. Some fear that under protection some sort of a monopoly will grow up. But I have no fears on that point. We can take care of our own monopolies by our laws; we would be able to rend them. But our laws do not apply to the foreign monopolies; we have no extraterritorial powers in that respect.

NO MONOPOLY IN DYES HERE

The National Aniline Co. is not a monopoly, has no connection with any monopoly in the American dye industry and has no agreement of any kind with any person or corporation for regulation of production or prices or division of prices or territory. This was the substance of the testimony of J. W. Newlean, president of the National Aniline & Chemical Co. "In fact," he went on, "there is nothing in the American dye and organic chemical industry even remotely approaching a monopoly."

"It seems to me that the maximum possible cost to the nation of surely keeping this industry, through a continuation of the selective embargo, is negligible compared with the risk of incalculable loss to the nation necessarily involved in any less certain measure of protection," declared Mr. Newlean. He added that there has been free competi-

tion, unrestricted in any way, under the selective embargo, with the result that the prices of American dyestuffs have steadily declined and are today lower than ever before.

Senator Shortridge announced at the close of Friday's session that John Nash McCullaugh, industrial manager for the National Association of Hosiery and Underwear Manufacturers, had disavowed authorship of or responsibility for the letter purporting to be signed for him and attacking the conduct of the hearing, which was left with the sub-committee recently by George Deming, who represented himself as counsel for the organization. Mr. McCullaugh asked that the letter be withdrawn from the records.

TARIFF COMMISSION STATISTICS

C. R. De Long, chief of the chemical division of the U. S. Tariff Commission, presented figures as to importations of dyestuffs in 1920. These showed that the total imports in that year, about 3,402,000 lb., constituted between 4 and 5 per cent of the total 1920 domestic production, which was approximately 88,000,000 lb.

Total domestic production of all coal-tar products in 1920 was 113,000,000 lb., and of this 88,000,000 lb. was dyes. Mr. De Long said that the total domestic production of all coal-tar products, including dyes, in 1921, estimated on the basis of incomplete reports, was from 40,000,000 to 50,000,000 lb. below the 113,000,000 lb. total of 1920. This decrease is due partly to overproduction in 1920 and partly to loss of export trade because of German competition.

PROMPT ACTION IN GRANTING IMPORT LICENSES

F. S. Dickson, chief of the dye and chemical section of the Treasury Department, declared that 90 per cent of the requests for import licenses received by his department are granted within 8 hours after they are received. The others are delayed in order to investigate the applicant's assertion that the American product will not meet his needs in point of price, quality or terms of delivery. About 5 per cent of the applications are refused.

The witness quoted specific examples where the consumers of dyes had requested licenses to import German dyes that are made in this country and the quality of which are such that the consumer actually did not know the difference. Asked his opinion as to existence of a monopoly, Mr. Dickson replied that he had seen no evidence of such thing.

Enamel Brick and Zirconium Refractories Discussed by Chicago Section, American Ceramic Society

Members of the Chicago Section, American Ceramic Society, met at the Hotel Morrison, Chicago, Tuesday evening, March 14. Ross C. Purdy, general secretary of the parent society, spoke informally of work being done by local sections and suggested the possibility of holding joint meetings with the Illinois Clay Manufacturers' Association.

D. F. Alberty, of the Northwestern Terra Cotta Co., discussed the manufacture of wire-cut single-fire enamel brick. The brick are formed on an auger machine with a steam-lubricated die, wire-cut on an American down-cut board-delivery cutting table and dried on pallets holding twelve brick each. The dried brick are sprayed with enamel and burnt in the same car-type muffle tunnel kiln which is used for terra cotta.

H. T. Bellamy, of the Western Electric Co., told of his experience with zirconium silicate brick in the crown of a small surface combustion glass tank. No spalling occurred with these brick and there seemed to be practically no deterioration from the fumes. In fact, it was possible to tear down the crown brick by brick and build it up again. In discussing this paper, W. V. Knowles, of Buckman & Pritchard, was called upon to describe the unique deposits of zircon and related minerals found on the Florida coast.

Congressmen to Inspect Muscle Shoals

The Senate Committee on Agriculture, which is considering the offers for the lease of Muscle Shoals, will leave Washington March 25 for a 5-day inspection of the plants. About twenty Senators will comprise the party. The House Committee on Military Affairs, which is likewise considering the offers, will also inspect the plants, the House having passed a resolution authorizing the visit.

Metric System Hearings Close With Rebuttal of Opposition Testimony

Hearings on the Britton-Ladd metric system bill have been definitely closed with the final appearance of representatives of the American Metric Association to rebut the testimony given in opposition to the legislation.

Senator McNary, in the final hearing, asked Howard Richards, secretary of the American Metric Association, if he expected the bill to be reported out in its present form. To this Mr. Richards replied:

"I certainly believe it should be in view of all the evidence that has been brought out. We are ready to consider any modifications, but unless there is some far more important objection than has been suggested so far, we are sincerely of the opinion that the bill is a good bill." Mr. Richards submitted a brief in which he attempted to show that the estimates of the cost to various manufacturers of the compulsory adoption of the metric system which were presented in the testimony of the opposition were unfair.

Theodore H. Miller of the De Laval Separator Co. testified that his company's stand in favor of the metric system was not due to the fact that certain parts used in its machines are made abroad, as intimated in the discussion before the National Council of the Chamber of Commerce. He stated that all parts have been manufactured in this country for machines built in the last 20 years.

Referring to the compulsory adoption of the metric system, Mr. Miller said:

"It is contended that the metric system can be used alongside any other system and that it should not be compulsory. It is fair to compare the system of measurement with the monetary system. The decimal monetary system was of necessity made the only legal standard of values. It was necessary because it had to be used nation-wide or not at all. If it had been optional we still would be using pounds, shillings and pence. Any system which must of necessity be nation-wide in its use must be declared to be the only standard."

Heavy Cut Prescribed by Appropriations Committee Would Reduce Chemical Warfare to Skeleton

The appropriation for the Chemical Warfare Service for the next fiscal year was cut from \$1,500,000, the amount carried in the budget, to \$500,000 by the Appropriations Committee of the House of Representatives. This drastic reduction means that only a skeleton organization can be maintained and the appropriation bill specifically states that the great manufacturing plants at Edgewood Arsenal are to be held in stand-by condition. With this small appropriation, the work of the Service practically will be limited to research and experimentation. It will mean that the trained personnel which has been gathered together in such a painstaking way must be disbanded for the most part.

Representative Anthony of Kansas, who is in charge of the War Department appropriation bill, explains that this action was taken because of the agreement reached at the Arms Conference. There is a remote possibility that the Senate will increase the item, possibly on the ground that it is the duty of the nation to its soldiers to have on hand at all times a sufficient supply of gas masks to insure their protection in case a possible enemy resort to the use of gas.

The attitude of Secretary of War Weeks was given during his appearance before the Appropriations Committee.

"Personally, I wish that chemical warfare might be banished from the earth forever," he said. "I do not think it will be banished until every nation agrees to its banishment and does so in good faith. I think we ought to carry out the provisions of the treaty in good faith, but just to what extent we should carry on experimentations in connection with this matter is a subject which I think should be fairly and thoroughly discussed."

"Take, as an example, the barrage. There is nothing said about eliminating the barrage. You might develop a much more effective smoke screen than existed in the last war. Just what we should do with the Chemical Warfare Service, outside of manufacturing, which I would not do at all, is a debatable question."

Trade Associations and Department of Commerce to Confer on Dissemination of Statistics

The Secretary of Commerce will hold a conference in Washington with representatives of trade associations the activities of which are national or interstate in their scope on April 12, 1922. It is the purpose of the meeting to get a list of trade associations that will furnish voluntarily to the Department of Commerce the classes of statistical information outlined in the correspondence between the Department of Commerce and the Department of Justice, published on Feb. 16, 1922. Means and methods will be discussed best adapted for collecting and forwarding to the Secretary of Commerce, for dissemination, the classes of statistical information outlined in the correspondence referred to, including the forms of reports that will be most suitable, for associations that are willing to furnish such statistical information.

Meeting of New Jersey Chemical Society

A large and appreciative audience heard two entertaining talks at the meeting of the New Jersey Chemical Society on March 13, in Newark, N. J. C. E. Davis, director of the research laboratory of the National Biscuit Co., gave an outline of the work being done by his laboratory in adapting chemistry and scientific methods to the biscuit industry. Besides the analysis of a large amount of raw material and miscellaneous supplies, the laboratory has worked out methods for the measuring of shortening and has studied the fundamentals of this action and found that increased shortness is merely increased lubrication in the dough, there being no evidence of chemical action. Leavening is also being studied and Dr. Bacon discussed the different forms of bread and biscuits and the different leavens used in them. In this connection he discussed the modern quick leavens, particularly monocalcium phosphate. He also described the modern processes for the preparation of edible gelatine, large quantities of which are used in the biscuit industry. He stated that recent research work has standardized the manufacture to such an extent that any desired properties can be obtained by the scientific maker.

Ellwood Hendrick, Consulting Editor of *CHEMICAL & METALLURGICAL ENGINEERING*, spoke on the subject, "Out of Chemistry—and In Again." Dr. Hendrick told in a highly entertaining manner of his experience as a student in Germany and amusing incidents in his business career.

Meeting of Executive Board of Federated American Engineering Societies

Steady advancement of engineering ideals both here and abroad and a growing sense of the need and importance of professional unity were outstanding features of the meeting in Chicago, on March 10, of the executive board of the American Engineering Council of the Federated American Engineering Societies. The report of President Mortimer E. Cooley, and of the executive secretary, L. W. Wallace, presented highly encouraging evidence of the favor with which the idea of engineering federation is being received in this and other countries.

A wide range of topics was considered by the board, whose sessions, largely attended, were presided over by President Cooley and the first vice-president, Calvert Townley of New York.

The executive board received a long report from Rudolph P. Miller of New York, its representative on the National Board of Jurisdictional Awards, stating that the United Brotherhood of Carpenters and Joiners of America have not been observing the decisions of the Jurisdictional Board and that the attitude of the carpenters was causing serious embarrassment to owners, architects, engineers, contractors and workmen in the building industry as well as being detrimental to the public interest. As a consequence of this report, the executive board adopted a resolution urging "that the members of the American Institute of Architects and of the F.A.E.S. insert in all specifications and contracts for building operations a stipulation that the decisions of the Jurisdictional Board shall be observed."

One of the liveliest discussions of the meeting of the

executive board arose from a resolution presented by Philip N. Moore of St. Louis "that the president of the F.A.E.S. be authorized to offer the Secretary of War the service of a committee of disinterested, distinguished and skillful engineers, to be selected by a committee of its executive board, for the purpose of making a thorough investigation of the geological, engineering and manufacturing possibilities of the Muscle Shoals power project; this committee to serve without compensation, save for necessary expense." The resolution was voted down.

Attention was called to the passage of the Lampert Patent Office bill and to the fact that much credit for the successful outcome of this legislation was due to the patent committee under the chairmanship of E. J. Prindle.

The Sterling bill for reclassification of federal employees was indorsed rather than the Lehlbach bill, since the salary schedules in the former are approximately 10 per cent higher than in the latter and conform more nearly with the report of the original reclassification committee.

Discussion of the proposed international federation of engineers to promote world peace centered on the details of effecting organization in the Americas. A committee was appointed to consider the whole situation as well as possible constitutional changes which would be necessary should the Canadian Institute of Engineers make application for membership.

Refractories Manufacturers' Association Holds Annual Meeting in Chicago

Departing somewhat from the custom of confining convention programs strictly to committee reports and other business matters, the Refractories Manufacturers' Association included a paper by W. A. Hull in the morning session, March 14, of its convention at the Drake Hotel, Chicago. Mr. Hull, who is chief of the refractories section, Bureau of Standards, spoke on the purchase of refractories with particular reference to government activities along these lines. It was found that the government system of purchasing left much to be desired. Through the energetic efforts of Mr. Hoover (who, he said, had taken the "secret" out of secretary) the Federal Specification Board had been formed. Conferences were held between producers and consumers—in the case of refractories the first conference discussed methods of testing, but the second was able to draw up a set of requirements for refractories for coal-fired boilers.

In his presidential address, J. D. Ramsay made a plea for a comprehensive industrial survey of the major operations in which refractory products are used. He suggested a committee of thirteen with a general chairman to consider service conditions in:

1. Blast furnaces, hot blast stoves.
2. Open-hearth furnaces, soaking pits.
3. Heating, puddling and forging furnaces.
4. All types of boilers.
5. Cement, lime and plaster kilns.
6. Window, plate, bottle and optical glass.
7. Annealing, malleableizing and air furnaces.
8. Water- and coal-gas generators, gas producers.
9. Cupolas and gray iron furnaces.
10. Oil refineries.
11. Zinc, lead and copper smelters.
12. All types of byproduct coke ovens.
13. All types of ceramic kilns.

Relations with the Mellon Institute of Industrial Research were brought out in the secretary's report and that of the committee on the Mellon Institute. Support of the fellowship has never been a serious drain on the association's resources because of an arrangement whereby research done for individual companies is paid for by the companies (at rates below those of independent laboratories, however). Thus in 5 years, over \$46,000 has been paid for individual research while the association as a whole has had to contribute only about \$7,000. In spite of business conditions during 1921, individual research for that year amounted to more than \$16,000, as compared with about \$13,000 in 1920.

Officers elected were: President, A. P. Taylor; vice-president, F. R. Valentine; treasurer, C. C. Edmonds.

Potash Producers Want Protection

A petition signed by forty-five American potash producers presenting their grievances has been received by Congress. The petition points out the serious effect of German competition on the American potash industry and appeals for relief in the form of moderate protection. Attention is called to the large investments that were made in potash developments during the war and which are now yielding no return because of the surplus of potash that is dumped on the market. It is claimed that German agents are conducting an extensive propaganda in this country to mislead Congress and the public about the needs of the American industry to the end that it may be denied the protection it seeks from foreign aggression.

Conservation of Supply and Continued Experiment Should Reduce Production Cost of Helium

Representative Anthony of Kansas, in discussing the army bill in the House, said that while it provides \$400,000 for helium investigations by the army and that a similar fund would probably be authorized for the navy, the Committee on Appropriations was not convinced that with existing facilities helium can be produced commercially.

The cost of government experiments in helium production for the army air service has amounted to \$8,016,000, according to testimony given before the Appropriations Committee by officers in charge of this work. When the work first started it cost \$1,700 to produce a thousand cubic feet of helium, and this has been reduced to \$83.71. The army has 2,400,000 cu.ft. of helium on hand. The government policy in regard to helium was announced to be one for scientific purposes and conservation for war purposes. The army authorities point out that it is desirable to establish continuous production to save the waste in the natural gas districts.

Advances have been made to the army by private interests for the development of helium production on a commercial scale, but no decision has been reached thereon. The army could provide storage facilities for 15 or 18 million cubic feet of helium. Army officers referred to a statement of the Bureau of Mines that the gas fields would probably be exhausted in 20 years. J. W. Davis, mechanical engineer of the Bureau of Mines, testified that with continued development, helium could be produced at a cost of \$30 per thousand cubic feet.

Atomic Disintegration of Tungsten Interests Joint Meeting of Mid-West A.C.S. Sections

Members of all sections of the American Chemical Society co-operating in the publication of the *Chemical Bulletin* gathered at Northwestern University at Evanston, Ill., on March 11 for the purpose of participating in a well-balanced intersectional program of social as well as scientific appeal.

At the afternoon session, Harrison E. Howe, editor of the *Journal of Industrial and Engineering Chemistry*, spoke on "Chemistry's Publication Problem." Mr. Howe discussed the editorial and advertising phases of the *Journal*, the News Service, and then outlined some of the plans for enabling the *Journal* to render greater service to the members. Teams representing Milwaukee and Chicago furnished entertainment in the form of an indoor baseball game in the attractive Patten Gymnasium. A score of 11 to 10 in favor of Chicago made up in some measure for the defeat suffered by Chicago at the first intersectional meeting.

After supper the evening program was continued in Harris Hall. Prof. H. B. Lemon of the University of Chicago read a paper outlining preliminary results of some remarkable work by Dr. G. L. Wendt and C. E. Irion on "The Atomic Disintegration of Tungsten." The method employed was suggested by the astronomical researches of Dr. J. J. Anderson of the Mt. Wilson Observatory. If a condenser charged at 100,000 volts is discharged suddenly through a very fine wire, the wire explodes and an instantaneous temperature of between 20,000 and 30,000 deg. C. is obtained. A pure tungsten wire 0.0004 mm. in diameter was exploded in a vacuum tube which gave no spectroscopic lines prior to the explosion. After the destruction of the wire, however, the characteristic lines of helium, hydrogen

and mercury were found, indicating atomic disintegration of the tungsten. It was voted unanimously to send a vote of congratulation to Dr. Wendt for this research.

Six group meetings provided ample variety of subject. Dr. H. I. Schlesinger demonstrated the application of absorption spectra methods to the study of the theory of the chamber process for sulphuric acid. Platinum black catalysis was considered by Dr. Roger Adams. Dr. E. J. Forbes spoke on the mineral metabolism of the milch cow; Prof. Edward Bartow on "Relation of High School and College Chemistry." The ladies and non-chemists witnessed a demonstration of the preparation of gelatine desserts and salads by Miss Alice Irwin.

John Arthur Wilson reviewed briefly the circumstances which had led to the development of his much-discussed method for tannin analysis. Attempts to check leather output against tannin input as indicated by the official method of analysis revealed that there was an apparent loss of about 50 per cent of the tannin. Further study showed that certain non-tans such as gallic acid which form hydrolyzable compounds with hide substance were included as tannin by the official method, the error varying with the amount of hide powder used. When the hide powder is washed free of these hydrolyzable substances, the results are constant regardless of the quantity of hide powder taken, and they check with the tannery yields. This forms the basis of Mr. Wilson's method, the washed, tanned hide powder being dried and weighed, giving a result strictly comparable with tannery practice.

Government Co-operating With Engineers in Standardization in Industries

At the request of Secretary of Commerce Hoover, the American Engineering Standards Committee has designated A. A. Stevenson, the retiring chairman of the committee, as a special representative to work with the department in the co-operation between the department's Division of Simplified Practice and the American Engineering Standards Committee. Mr. Stevenson, who is a past president of the American Society for Testing Materials and has had a most extensive experience in standardization work, is vice-president, in charge of manufacture, of the Standard Steel Works Co., which is a subsidiary of the Baldwin Locomotive Works.

The Division of Simplified Practice is a co-ordinating unit of the Department of Commerce assisting in those reductions of excessive variety and other simplifications which many industries are undertaking in order to decrease the cost of production and distribution of manufactured articles. The work of the division was organized in the latter part of 1921 and is now actively under way.

The American Engineering Standards Committee, which serves as a national clearing house for a broad field of engineering and industrial standardization, has offered Secretary Hoover the use of its machinery in carrying out the detailed work on technical projects initiated in the simplification program of the Department of Commerce. The committee has been actively at work somewhat over 2 years, during which time it has brought about a large measure of industry-wide co-operation. In this work more than a hundred national organizations are participating through representatives officially designated by them. The formulation of the standard for each specific project is in the hands of a working committee made up of representatives officially designated by the various bodies concerned. Eighteen standards have received formal approval as nationally recognized standards, and work on more than sixty other projects is in various stages of development. The American Engineering Standards Committee is maintained jointly by twenty-nine national organizations, including five departments of the federal government, nine national engineering societies, and fifteen national industrial associations.

There are now similar national industrial standardizing bodies in thirteen foreign countries, all but one of which were formed during or since the war. Of these the British and the German work is the most extensive, but active and important work is going forward in other countries.

Fish Commission Warns Against Drastic Pollution Prevention Measures

Congress has received a petition from the New Jersey Legislature urging passage of the Appleby bill to protect coastal waters from pollution by fuel oil and waste from chemical and industrial plants.

Warning was given Congress by the U. S. Fish Commission not to injure industry by proposed legislation to prohibit the discharge of oil and other acid wastes into navigable streams in an attempt to save fish from the effect of polluted waters. Officials of the fishery bureau point out that the pending bills before Congress against pollution would practically wipe out some industries on the theory that all pollution was injurious to fisheries, while as a matter of fact it was not known that they are so injurious. They admit that oil pollution is injurious to the fish but say that an attempt to protect fish by drastic legislation without fundamental information might work serious effects on the general business of the country. For example, it is known that the coal mines of western Pennsylvania cause pollution of the Ohio River to the injury of the fish, but obviously this is not sufficient ground for closing those mines. Authority to employ chemists to make a complete study of the effect of pollution on fish was requested.

Personal

R. I. BASHFORD, assistant general superintendent of the Grasselli Powder Co., who has been in charge of its high explosives plants for the past 2 years, has tendered his resignation to become effective April 1.

Dr. ERNEST B. BENDER, director of the Redpath Laboratory of E. I. du Pont de Nemours & Co., is making a brief trip to England in connection with the work of the laboratory on motion picture film.

A. NELSON CHASE, superintendent of the Forcite Works of the Atlas Powder Co., at Landing, N. J., has been transferred to the Darco Corporation's decolorizing carbon plant at Marshall, Tex., as superintendent. This plant is in process of construction and it is expected will be ready for operation about May 1.

Dr. EMIL COLLET of Christiania, Norway, is making a tour of the United States in the interest of Norwegian chemical companies.

R. D. COOKE, chief chemist at the plant of the Columbian Enameling & Stamping Co., Terre Haute, Ind., gave an interesting address before the members of the Indiana Section of the American Chemical Society at the Chamber of Commerce Building, Indianapolis, on March 10, on "Sheet Steel Enamels and Enameling."

JOHN A. ELLIOTT of Pittsburgh has been elected president of the Brinkley Producing & Refining Co. Headquarters of the company are being moved from New York City to Pittsburgh.

W. B. EMMERT, formerly president of the United Central Oil Co., now consolidated with the White Oil Corporation, 66 Broad St., New York, has been elected president of the latter company. He will succeed P. J. White, who becomes chairman of the board of directors.

JOHN R. FREEMAN, JR., returned recently to the Bureau of Standards from a 7 months' trip to Europe, where he visited, for the Bureau of Standards, the principal metallurgical laboratories of France, Germany and England. While in England he worked for about 2 months in the metallurgical department of the National Physical Laboratories under Dr. Walter Rosenhain.

W. A. GIBSON has been transferred from superintendent of foundry for the Owens Bottle Co. to master mechanic for the Libbey Owens Sheet Glass Co., at Charleston, W. Va.

WILLIAM R. HARRIS has been re-elected president of the Monroe Paper Products Co., Monroe, Mich.

H. T. HERRICK, formerly of the National Aniline & Chemical Co. at Buffalo, N. Y., and more recently with the American Aniline Products Co. at Lock Haven, Pa., is now operating chemist of the By-Products Steel Corporation at Weirton, W. Va.

A. C. LANSING has left his fellowship at the School of Mines at Golden, Col., to become chemist with the Lightfoot Schultz Co., soap manufacturer, of Hoboken, N. J.

Dr. W. LEE LEWIS of Northwestern University addressed a joint luncheon meeting of the Chicago Chemists Club and the City Club, Tuesday, March 7, on the subject "Is the Elimination of Gas Warfare Feasible?"

T. A. MITCHELL, chemical engineer, has just returned to the United States after spending 5 years abroad, where he was director of the French branch of the Norsk Aluminum Co. He is now at 30 Church St., New York City, associated with Rogers, Brown & Co.

ROSS C. PURDY, secretary of the American Ceramic Society, addressed the annual convention of Illinois Clay Manufacturers' Association at the LaSalle Hotel, Chicago, March 14, on "The Relation of State Associations to Local Sections of the American Ceramic Society."

CHARLES RUSS RICHARDS, dean of engineering and director of the experimental engineering department of the University of Illinois, has been elected president of Lehigh University. He succeeds Dr. Henry S. Drinker, now president emeritus at Lehigh. Mr. Richards is a graduate of Purdue University and a post-graduate of Cornell.

L. B. RIDDLE has been appointed manager of production for the Shaffer Oil & Refining Co., Chicago, Ill. He recently resigned as assistant manager of production for the Pure Oil Co. of the same city.

Dr. HUGO SCHLATTER, formerly chief of the chemical products division of the Hercules Powder Co., has recently returned from an extended visit to Europe and has opened an office as consulting engineer in the Stephen Girard Building, Philadelphia, Pa. He will specialize in the chemistry of cellulose and its products.

Dr. EDWIN E. SLOSSON spoke on "The Popularization of Science" at a luncheon forum of the City Club, Chicago, on March 14.

Prof. M. DEKAY THOMPSON of the Massachusetts Institute of Technology, Cambridge, Mass., addressed the Franklin Institute, March 5, on the subject "Recent Progress in Applied Electrochemistry."

Obituary

WILLIAM L. PRIZER, manager of the Vacuum Oil Co., New York City, died on March 6, at his residence in New York, at the age of 68 years.

CHARLES C. SPRINGER, managing director of the Mt. Tom Sulphite Pulp Co., Boston, Mass., and for many years identified with the pulp and paper industry, died at his apartments in the Hotel Vendome, on March 9.

Dr. CHARLES W. WAIDNER, chief physicist of the Bureau of Standards, died at his home in Washington, D. C., on March 10 after a protracted illness. He was born in Baltimore, March 6, 1873, and received his early education in the public and private schools there, after which he was graduated from Johns Hopkins University and later received the degree Ph.D. from that institution. He taught for several years, and in 1901 entered the Bureau of Standards, and was connected with that institution as organizer and chief of the work on heat measurements and thermometry practically since the establishment of the bureau. His work was mainly in the fields of temperature and heat measurements and apparatus for the study of thermal phenomena. During recent years his particular problem had been direction of the work on the determination of physical constants used in engineering, especially fireproofing of structural materials and refrigerating engineering. The work on automotive engines also was under his charge.

Market Conditions

IN CHEMICAL, METALLURGICAL AND ALLIED INDUSTRIES

A Survey of the Economic and Commercial Factors That Influence Trade in Chemicals and Related Commodities—Prevailing Prices and Market Letters From Principal Industrial Centers

Wage Comparisons in the Chemical and Allied Industries

Manufacturers in every line of industry are impressed by the urgent need for lower costs of production. Naturally the problems of labor are among the first to absorb their attention, for in this direction lies the obvious, even though perhaps the most difficult, path to lower costs. Wages in most branches of business have already been reduced and in certain industries there is abundant evidence that further reductions are necessary if the manufacturer is to meet the

to offer adequate basis for comparison. The monthly reports of the Industrial Commissioner of New York may, however, be regarded as an exception, for comprehensive statistics of employment and wages in New York State are now published fairly promptly.

In Table I are given some of the more recent figures for the number of employees and weekly wages in representative New York factories engaged in the production of chemicals and related products. It will be noted that the group "chemicals, oils and paints" exhibits the same general trend as the total for all industries, but has a noticeably higher

TABLE I—EMPLOYEES AND AVERAGE WEEKLY EARNINGS IN REPRESENTATIVE NEW YORK STATE FACTORIES FOR CHEMICALS AND ALLIED PRODUCTS, FOR DECEMBER, 1914 TO 1921
(Compiled under direction of the Industrial Commissioner of New York State)

Chemical and Allied Industries	Total State		New York City		Average Weekly Wages in New York State					Average Weekly Wages in New York City				
	Estab-lish-ments	Em-ployees†	Estab-lish-ments	Em-ployees†	1921	1920	1917	1915	1914	1921	1920	1917	1915	1914
Stone, clay and glass products.....					\$25.00	\$30.98	\$18.32	\$14.08	\$13.94	\$30.14	\$34.39	\$18.55	\$15.60	\$16.53
Miscellaneous stone and mineral products.....					27.78	33.02	19.64	16.54	18.47	38.73	41.76	22.45	20.50	21.44
Lime, cement and plaster.....	73	11,440	26	2,442	26.07	32.42	18.16	12.96	13.38	22.99	32.55	17.86	14.51	15.43
Brick, tile and pottery.....					21.99	29.07	16.19	11.72	11.53	25.95	31.44	18.42	13.21	10.18
Glass.....					25.73	29.96	18.53	14.99	14.23	28.82	30.24	20.18	14.40	15.30
Metals, Mchry. and Conveyances.....					26.46	31.80	20.84	15.61	14.24	27.39	31.58	18.54	15.30	14.01
Gold, silver and precious stones.....					27.14	33.46	18.99	16.56	14.24	31.46	31.62	18.91	17.72	16.98
Brass, copper, aluminum, etc.....					22.09	27.41	18.62	13.18	12.73	23.37	27.67	16.89	13.02	12.64
Pig iron and rolling mill products.....	346	142,606	96	30,172	24.53	36.65	27.70	18.01	16.63					
Structural and architectural iron wk.....					30.12	33.10	20.50	16.62	15.31	33.26	34.34	20.09	16.96	5.99
Sheet metal work and hardware.....					24.65	27.77	17.24	13.03	12.20	24.33	27.41	16.23	12.08	10.33
Leather and Rubber Goods.....					24.11	25.26	16.75	12.71	11.88	26.86	28.65	17.08	13.03	12.10
Leather.....					21.05	25.49	18.21	12.26	11.04					
Misc. leather and canvas goods.....	141	40,663	75	13,578	24.08	23.87	14.57	11.66	10.99	28.74	28.75	15.20	11.80	11.29
Rubber and gutta percha goods.....					25.08	24.90	15.97	11.66	10.93	26.06	26.02	16.33	12.48	11.60
Pearl, horn, bone, celluloid, hair, etc.....					21.38	22.39	13.79	10.31	9.62	23.49	25.06	13.59	10.20	9.27
Chemicals, Oils, Paints, Etc.....					25.99	28.04	18.00	13.90	13.64	25.91	26.90	16.93	13.24	13.37
Drugs and chemicals.....					23.82	26.09	16.68	13.69	14.57	20.35	21.19	13.52	11.39	12.88
Paints, dyes and colors.....	57	25,918	29	897	25.39	28.38	16.43	14.59	14.43	25.87	28.26	16.35	14.45	14.32
Animal and mineral oil products.....					26.30	28.17	19.03	13.69	13.35	28.11	28.99	19.09	13.57	13.32
Miscellaneous chemical products.....					27.17	29.37	17.96	14.25	13.17	27.78	31.76	19.20	13.52	11.55
Paper.....	167	48,719	92	29,897	26.93	31.06	18.96	14.12	13.32	*	*	*	*	*
Total for all industries.....	1,648	471,431	780	177,855	\$24.91	\$28.35	\$17.71	\$13.49	\$12.56	\$26.56	\$28.89	\$16.61	\$13.45	\$12.81

* Reports do not cover a sufficient number of employees to permit the publication of an average weekly earning.

† Includes all employees in both office and shop. It is commonly the case that office salaries are higher than the average weekly earnings of shop employees. However, the office employees form such a small percentage of the total number of workers that their effect, in the computation of the average earnings, is negligible.

competition which is developing with business revival. It is perhaps worth while, therefore, to give some consideration to the trend of employment and to wage levels both in this country and abroad.

Chemical and metallurgical manufacturers, unfortunately, can obtain relatively little published information regarding wage conditions outside of their own plants. To be sure, some compilations are made at infrequent intervals by the federal government and by labor departments in some of the states, but for the most part these data are not published soon enough to be of value or are too fragmentary

wage level. However, maximum wages paid in December, 1920, averaged \$28.04 for this group, as compared with \$28.35 for all industries. The metals group appears to have received the highest wages most consistently, averaging \$31.80 for December, 1920, while one subdivision, pig-iron and rolling mill products, reached as high as \$36.65 per

TABLE IA—WAGES AND NUMBER OF EMPLOYEES IN THE DYE AND COAL-TAR CHEMICAL INDUSTRIES IN 1920
(From U. S. Tariff Commission Census of Dyes, etc.)

Wages per Week	Number of Employees at Each Specified Wage Engaged in Manufacturing Operations			Percentage Receiving Each Specified Wage Of All	
	Chemists and Technically Trained Men	Men Without Technical Training	All Employees	Chemists and Technically Trained Men	Of All Men Without Technical Training
Under \$10.....	3	30	33	0.12	0.15
\$10, but under \$15.....	15	303	318	0.59	1.54
\$15, but under \$20.....	55	618	673	2.15	3.15
\$20, but under \$25.....	72	2,038	2,110	2.82	10.38
\$25, but under \$30.....	118	3,837	3,955	4.63	19.55
\$30, but under \$35.....	201	5,564	5,765	7.88	28.34
\$35, but under \$40.....	242	3,431	3,673	9.49	17.47
\$40, but under \$45.....	431	1,813	2,244	16.90	9.23
\$45, but under \$50.....	214	1,049	1,263	8.39	5.34
\$50, but under \$75.....	670	907	1,577	26.25	4.62
\$75 and over.....	530	46	576	20.78	0.23
Total.....	2,551	19,636	22,187	100.00	100.00

CHEMICAL & METALLURGICAL ENGINEERING'S WEIGHTED INDEX OF CHEMICAL PRICES

Base = 100 for the year July 1, 1913, to June 30, 1914

This week	157.49
Last week	157.13
March, 1921	157
March, 1920	252
April, 1918 (high).....	286
April, 1921 (low).....	140

Of the twenty-five commodities included in this index number, the prices of five have advanced during the past week, two have declined and the others have remained unchanged. The rise in the prices of ammonium sulphate, barium chloride, caustic potash, caustic soda and soda ash more than offset the lower prices for linseed oil and citric acid.

week. The leather group paid the lowest average wage in both 1920 and 1921, but the decrease was much less than in the case of any other group. The most striking wage reduction was in the ceramic industries, where the decrease of \$5.98 per week in 1921 was equivalent to approximately 20 per cent of the 1920 wage and to 36 per cent of the 1914 figure.

Using the number of employees in June, 1914, as a basis of 100, the ratio in December, 1921, for the group "stone, clay and glass products" was 79; for the metals group, 95; for leather and rubber, 111; for chemicals, 102; and for paper, 93.

The most recent compilation of wages in the dye and coal-tar chemicals industry is contained in the United States Tariff Commission's "Census of Dyes and Coal-Tar Chemicals, 1920." These figures, reproduced in Table IA, are for the year 1920, and have therefore lost much of their value, for since that time there have been drastic reductions both in wages and number of employees.

INTERNATIONAL WAGE COMPARISONS

The recent report of the Tariff Commission on "Depreciated Exchange and International Trade" contains a very interesting study of wages and living conditions within some of the countries whose exchanges have suffered depreciation. Commodity prices may be varied almost directly with the exchange, but wage rates shift more slowly and thus those countries whose currencies have depreciated most may derive a corresponding competitive advantage because of low wages as compared with the higher international

TABLE II—INTERNATIONAL WAGE COMPARISONS IN THE CHEMICAL INDUSTRY*
(Rate per hour as of May, 1921.)

Occupation	United States ¹	Great Britain ² At Current Exchange	Germany ³ At Current Exchange	Equivalent Purchasing Power ⁴	Equivalent in Cost of Living ⁵
Laborers:					
Male	\$0.390	\$0.271	\$0.094	\$0.155	\$0.211
Female	.272	.172	.053	.088	.120
Foremen:					
Chemical operators	.674		.097	.168	.228
Mech. operators	.557		.096	.159	.216
Process men:					
Assistants	.500				
Primary	.683	.312	.094	.155	.211
Secondary	.544				

* Compiled and published by U. S. Tariff Commission.

¹ Monthly Labor Review for May, 1921.

² Ministry of Labor, "Rates and Hours of Wages," December, 1920. Amended by the *Labour Gazette*, May, 1921.

³ German basic wages reported by *Statistischer Reichsamt* for February, 1920, readjusted to May, 1921, by application of the wage index number published by the *Frankfurter Zeitung* for the Frankfurt district.

⁴ Equivalent purchasing power based on United States and German wholesale price indices.

⁵ Equivalent purchasing power based on relative costs of living in United States and Germany.

TABLE III—INTERNATIONAL WAGE COMPARISONS IN THE METALLURGICAL INDUSTRY*
(Rate per hour as of May, 1921.)

Occupation	United States ¹	Great Britain ² At Current Exchange	Germany ³ At Current Exchange	Equivalent Purchasing Power ⁴	Equivalent in Cost of Living ⁵
Toolmakers	\$0.880	\$0.400	\$0.109	\$0.182	\$0.246
Chargers for blast furnaces	.400	.350	.090	.150	.203
Other blast-furnace workers	.330	.270	.087	.145	.197
Stamped or pressed metal workers	.600	.200	.098	.162	.220
Borers	.550	.370	.099	.165	.230
Turners	.780	.458	.098	.163	.221
Millers	.650	.370	.107	.179	.242
Armature winders	.800	.458	.097	.160	.228
Pattern makers	.800	.479	.104	.174	.236
Boilersmiths	.800	.468	.106	.177	.239
Strikers	.500	.340	.090	.150	.203
Brass dressers	.550	.334	.116	.192	.261
Brass casters	.830	.413	.097	.161	.218
Brass polishers	.550	.354	.105	.165	.224
Brass molders	.880	.355	.096	.159	.215

* Compiled and published by U. S. Tariff Commission.

¹ Average estimate by experts of the Tariff Commission of wages paid in the chief commercial districts in the metallurgical industry.

² The *Labour Gazette* (British).

³ German basic wages reported by *Statistischer Reichsamt* for February, 1920, readjusted to May, 1921, by application of the wage index number published by the *Frankfurter Zeitung* for the Frankfurt district.

⁴ Equivalent purchasing power based on United States and German wholesale price indices.

⁵ Equivalent purchasing power based on relative costs of living in United States and Germany.

TABLE IV—FOREIGN WAGES IN CHEMICAL INDUSTRIES
COMPILED BY U. S. TARIFF COMMISSION FROM PRIVATE SOURCES
OF INFORMATION, JANUARY-JULY, 1921

Occupation	France— Conversions Made at \$0.074 Per Franc	Italy— Conversions Made at \$0.042 Per Lire	Occupation	France— Conversions Made at \$0.074 Per Franc	Italy— Conversions Made at \$0.042 Per Lire
Common laborers..	\$0.111	\$0.121	Assistant chemists		
Do.	.130		or aids	.185	
Do.	.157	.089	Do.	.315	
Do.	.150		Do.	.370	
Do.	.130	.065	Chemical engineers		.210
Do.	.143	.084	Do.		.263
Skilled labor or process men....		.084	Pipe fitters	.222	
Do.	.139	.105	Do.	.259	
Do.	.167	.147	Machinists	.226	
Do.	.173	.112	Do.	.255	
Do.	.157		Blacksmiths	.200	
Do.	.305		Do.	.255	
Control or plant chemists		.167	Carpenters	.200	
Do.	.231	.210	Do.	.229	
Do.	.444		Firemen	.160	
Do.	.694		Do.	.175	
Do.	.207		Plant operatives (unskilled)	.139	
Research chemists		.167	Do.	.201	
Do.	.370	.210	Yardmen	.134	
Do.	.781		Do.	.175	
			Plant foremen	.185	
			Do.	.278	

value of their products. In this connection the Commission makes the following statement:

The comparative wages in the chemical and metallurgical industries are especially significant. The standard wage in the United States appears to be about 50c. to 75c. per hour and from 30c. to 45c. per hour in England. Germany, on the other hand, shows a rate averaging about 10c. per hour at current exchange, about 18c. per hour in terms of the purchasing power over commodities at wholesale, and from 20c. to 25c. per hour in terms of the cost of living. Inasmuch as many chemical products in Germany are competing directly with similar ones produced in England and the United States, the wage rate at 10c. per hour at current exchange becomes an important factor.

It will be observed in Tables II and III that in the case of Germany, the wages paid in depreciated paper money are converted to American currency in three ways—viz., (1) at the current rate of exchange quoted in New York, (2) at a rate based on German and American wholesale price

TABLE V—WAGES IN THE GERMAN CHEMICAL INDUSTRY AND THE MINIMUM COST OF LIVING, 489 ESTABLISHMENTS

(Quoted from *Statistische Reichsamt* by Consul Maurice Parmelee in special report to the United States Bureau of Foreign and Domestic Commerce under date of May 22, 1921.)

	Skilled Workers 1914		Skilled Workers 1920		Unskilled Workers 1914		Unskilled Workers 1920	
	Cost of Living*	Wages	Cost of Living*	Wages	Cost of Living*	Wages	Cost of Living*	Wages
Unmarried men	100	232	100	188	100	161	100	175
Married couple	100	174	100	131	100	121	100	122
Married couple with 1 child	100	162	100	113	100	106	100	107
Married couple with 2 children	100	135	100	103	100	94	100	97

* Includes food, fuel, light, and rent only.

index numbers and therefore on the basis of relative purchasing power and, (3) at a rate based on the cost of living for an ordinary family in the two countries. In effect this is a translation of nominal to real wages.

These calculations are necessary because of two factors of peculiar significance in the German situation. These are low rents and food subsidies. The report points out that "because of governmental control, rents are only 50 to 60 per cent higher than they were in 1914, an item which holds down the cost of living to a great extent. The food subsidies take the form of government purchases, largely of imported commodities, at the world market price

and their resale to German consumers at a substantially lower figure."

In addition to the wages from official sources, the Tariff Commission has obtained some rates from American firms having definite knowledge of foreign conditions. From these data, which are reproduced in Table IV, it will be seen that wages in France and Italy at current rates of exchange were from 15c. to 25c. per hour for common labor and correspondingly more for skilled technicians. These rates appear to be about halfway between the rate for similar occupations in Germany and England and less than half the rates in the United States.

A special consular report to the Department of Commerce, under the date of May 22, 1921, gives some interesting information on the relation between the cost of living and wages in the German chemical industries in 1914 and 1921. This compilation, which includes data from 489 establishments, is shown in Table V. In commenting on this table Consul Parmelee says:

These figures illustrate very pointedly that, while skilled workers in this industry were apparently not so well remunerated in 1920 as in 1914 in proportion to the cost of living, the unskilled workers were better remunerated in 1920 than in 1914 in proportion to the cost of living. In fact, by the year 1920 the unskilled workers had attained almost as high a level of remuneration as the skilled workers.

Imports and Exports of Chemicals in January

Figures covering imports and exports during January contain little of encouragement to the chemical industries. The total value of exports in January was \$7,919,896. This compares with \$16,833,454, the value of the exports in January of 1921. The imports in January of this year were valued at \$7,517,817. This compares with \$12,241,424 in January of last year.

The decrease in imports was confined entirely to the free list. Durable chemicals increased slightly over the value of those brought into the country in January, 1921. Imports of coal-tar products were less in January by nearly one-half. The value of all coal-tar products imported in January was \$720,908. There was only a slight falling off in the value of gums imported. The January figure was \$7,272,280. There was a very material increase in imports of carbonate of and hydrate of potash. Increases in the imports of cyanide of soda and muriate of ammonia were noted, but the imports of calcium products fell to nearly one-third the volume of the January, 1921, imports.

Exports of benzene in January were 2,178,420 lb., double the exports of January, 1921. Exports of crude distillates of coal tar fell off decidedly. Exports of colors, dyes and stains of coal-tar origin fell to one-third of the volume in which they were exported in January, 1921. Sulphuric was the only acid moving in volume during January, but shipments were much smaller than in January of last year. The slump also affected in about the same proportion the shipment abroad of acetic, nitric, boric and lactic acids. Calcium carbide and chloride of lime moved in only one-half the rate at which shipments were made in January, 1921.

The New York Market

NEW YORK, March 20, 1922.

There has been a decided expansion in the volume of business transacted in the chemical market during the past week due to both foreign and domestic buying. Present low prices for caustic soda have noticeably improved export business in this chemical. Heavy sales were recorded to Italy, Germany, South America and Japan. There are some interests who expressed the opinion that caustic soda will touch 4c. per lb. before the close of the month. Although the market on soda ash of late is somewhat steadier, it is not showing much of a tendency to strengthen in sympathy with caustic soda. Nitrite of soda reached some new high levels on spot due to the very scant offerings. Yellow prussiate of soda was much easier. Quotations during the week recorded a net loss of 3c. per lb. Prices opened at 18½c. per lb. and closed the week at 17½c. Producers of carbon tetrachloride quote lower prices on round lots, but are

sustaining recent levels on regular small-lot inquiries. Recent importations of glauber's salt have had a depressing effect on the market and prices on foreign material were generally below 1c. per lb. This is a fraction under pre-war figures. The bromides were very much firmer and domestic producers have advanced prices considerably on potassium bromide, which is quoted at 23@24c. per lb. Imported material was very scarce and brought up to 16c. per lb. Barium chloride continued its rise. Sulphate of ammonia is exceedingly scarce in the resale market and prices showed a net advance to 3½c. with the demand active. Tartaric acid has shown an advancing tendency and the market was very firm with offerings of imported material more restricted.

THE COMMODITY MARKETS

Arsenic.—Continues very promising and the tone of the market is firm. Dealers are placing small-lot business at 7@7½c. per lb. In some directions 7½c. seems to be the prevailing figure, while others are even quoting as high as 8c. per lb.

Carbon Tetrachloride.—Leading manufacturers are offering carlots as low as 9½c. per lb. Small quantities command a premium and prices extend all the way up to 12c., according to seller and quantity.

Caustic Soda.—Prices for export remain firm and the market shows a tendency to advance among second-hand merchants. Quotations in these quarters are held at \$3.70 per 100 lb. f.a.s., for March shipment, \$3.60 for April and \$3.50 for May-June. The export inquiry is very active and some sellers are sold up for April. Producers' contract prices are sustained at \$2.50 per 100 lb., basis 60 per cent, f.o.b. works, in carload lots.

Epsom Salts.—Imported salts are offered at \$2.60 per 100 lb. for the U.S.P. Some domestic material has been sold down to \$2.50 at the works. The technical grade is not finding any ready market and goods are offered down to 1c. per lb.

Fluoride of Soda.—Leading factors in this commodity were not eager to quote below 10c. per lb., and stated that small consuming orders were being booked at 11c. Offerings are rather scarce and the tone of the market appears quite firm.

Glauber's Salt.—Imported material is offered at 95c. per 100 lb. in bags, on spot and 90c. to arrive. Barrels are quoted at 1.10@1.20, depending on quantity. Domestic goods are held at 1¼@1½c. per lb. Buyers are showing some additional interest of late.

Nickel Salts.—Spot material is not plentiful in the single or double grades and the general condition of the market is reported quite steady. Leading factors state that business in both varieties is going through at 11c. per lb.

Nitrite of Soda.—Scarcity in this chemical is very pronounced at present and holders are limiting their offerings. In first hand quarters it was stated that 9c. per lb. could be done on a firm order, while the majority of dealers are demanding 9½c. per lb. for spot goods. Some large holders of imported material have entirely withdrawn from the market, as they are convinced that higher prices will soon prevail.

Prussiate of Soda.—Lower prices are quoted for spot material and while 17½c. per lb. was quoted in some directions, it was intimated that 17½c. could be done on firm orders. The demand seems to have been temporarily satisfied so far as urgent requirements are concerned and a keener competition has developed.

WAXES

Beeswax.—Trading in crude beeswax was slow, but prices held up steady in sympathy with other markets. African crude on spot was available at 15c. per lb. Brazilian crude was quoted nominally at 21@24c. per lb., pure white on spot at 35@40c. per lb.

Montan Wax.—The shipment market held at 4¼@4½c. per lb., with spot material quoted at 4¼@5c. The demand was merely routine.

Paraffine Wax.—The general trend of the market showed

only a slight improvement. Leading producers did not attempt to force business, but tried to sustain current quotations. Match wax attracted some attention and with offerings rather light, prices ruled firm at 4½@4¾c. per lb. Fully refined wax of 125-127 deg. melting point sold at 3½c. per lb., with the 130-132 deg. at 4c. per lb.

Carnauba Wax.—Advices from primary markets indicated a firmer market but prices here did not change a great deal, for the demand has fallen off. No. 3 North Country was quoted at 15½@16c. per lb. No. 2 North Country was steady at 25@26c. pr. lb.

The St. Louis Market

ST. LOUIS, March 16, 1922.

The activity in the local market for industrial chemicals continues and the prospects for the future are very promising. Furthermore, the market is much firmer and the demand for spot and future business is increasing steadily in volume. Many of the weak spots caused by the foreign competition are being eliminated, due to the continued rise of sterling exchange. The local market is very optimistic and producers are putting great confidence in the future.

ALKALIS

There has been no change in *caustic* for some time and the present conditions would indicate firmness at prevailing price, one producer of *electrolytic caustic* having withdrawn from this market, being sold up for the time being. *Soda ash* continues to move steadily at prevailing market in less than carlots, and carlots can be purchased as low as \$1.75 per 100 lb. in bags f.o.b. St. Louis. *Sodium bicarbonate* is being offered freely at \$2.50 per 100 lb. in 1- to 5-bbl. lots. A new factor in the *sul soda* market is offering the regular case goods, 36 packages of 2½ lb. each, at \$2.25 delivered buyer's door, with barrels at \$1.75.

GENERAL AND SPECIAL CHEMICALS

The heavy *commercial mineral acids* are still very active with no change in price and market firm. The disturbing element which existed some time ago is gradually coming into line with the present prices. *Citric acid* is moving somewhat better, but there is still lacking the real demand usually expected at this time of the year. Prices are firm. *Carbolic acid crystals, U.S.P.*, is one of the commodities which moves through regular channels and the demand remains practically the same from month to month. Owing to the scarcity of *white arsenic* the market is much stronger and spot lots are now being quoted at 6@7½c. f.o.b. producers' works. Domestic manufacturers of *bromides* have this week advanced their price on the *potash salts* 4c. per lb., other *bromides* remaining unchanged. There is quite a bit of activity in the *bromide* market and business of large volume is passing. There has been practically no cessation in the demand for *bismuth salts* and *iodide salts* for the past 12 months, and today the movement is of as large a volume as at any time. Producers report that they are favorably situated to meet the continued increase. *Carbon bisulphide* is in brisk demand. *Carbon tetrachloride* has not been active and prices are on the easy side. The *copperas* situation is not any easier today than it was several weeks ago. Producers are still unable to take care of business other than their regular customers. Quotations remain the same. *Glycerine* has not changed since our last report and is still being offered at 16c. in drums with a good demand. *Sulphur* has stiffened somewhat, as high as \$2.10 being quoted in some instances. A steady demand for *zinc sulphate technical* is still evident and is being quoted at \$2.95 in carlots f.o.b. St. Louis.

VEGETABLE OILS AND NAVAL STORES

Castor oil remains firm and in good demand, the price of 13½c. in drums prevailing. *Linseed oil* is being quoted today at 87c. bas's raw oil, a drop of 2c. within the last 2 days. *Turpentine* offered today at 90c. in barrels, 87c. in drums, a drop of 1½c. since our last report.

PAINT MATERIALS

Our anticipated advance in price of *French ochre* stimulated buying in the paint trade recently, there being a rush to get under cover before the new price went into effect. Aside from this the paint trade is very slow at a period when it should be booming.

The Iron and Steel Market

PITTSBURGH, March 17, 1922.

The chief point about the steel market now is whether demand will continue at its recent rate, not whether it will increase farther. The rate of steel ingot production in the past 3 weeks has ranged between 29,000,000 and 30,000,000 tons a year, while the two best pre-war years, 1912 and 1913, each showed a production of 30,275,000 tons. The decrease in exports is sufficient to cover the difference between these figures, so production for domestic consumption is now running at the average rate in the two best years before the war. As the general industrial or business situation in the country is regarded as unsatisfactory, rather than as measuring up to the highest standard before the war, there cannot be much complaint as to this item of the volume of steel demand, and the real market question is whether it will continue indefinitely, increasing as general and basic conditions improve.

Considering the time of year and the fears of not a few buyers that production and shipment of steel might be curtailed by the expected coal strike April 1, there is reason to suspect that a portion of the recent steel buying has been for stocking purposes.

There is no prospect that the coal strike will handicap the steel mills. It is unlikely, though it is not impossible, that production in the non-union fields, like the Connellsville region, will be interfered with by sympathetic strikes, and the non-union capacity is fairly large relative to the present rate of coal consumption. Consumers of coal are known to have been stocking coal and the weakness in the coal markets in most districts in the past fortnight, with definite declines in prices in some districts, including Pittsburgh, indicates that consumers are not being caught with smaller stocks than they think necessary.

With domestic demand for steel running at approximately the rate of 1912 and 1913 it is interesting to note the differences in distribution. Production of rails and plates is much less, while production of tin plates and sheets is much greater. In tubular goods there is more tonnage in standard pipe and less in oil country goods. In wire mill products there is less in fencing and probably more in nails. In bars and structural shapes there is probably little difference.

STEEL PRICES

As to prices, the steel market is probably a trifle stiffer, on the whole, than a week or two ago. There has been an effort to get bars, shapes and plates up to 1.50c. as a stabilized figure, and this has succeeded to the extent that quotations under 1.40c. are now relatively uncommon. Shading in tubular goods seems to be a trifle less extensive. Sheets show no change, as they have been rigid right along, at 3c. for black and 4c. for galvanized. Hoops are a shade stronger, with concessions under 1.80c. uncommon and 1.90c. well maintained on cut hoops. Nails, however, show more frequent concessions than formerly from the regular \$2.40 price.

PIG IRON

Two sales of basic pig iron at \$18 valley furnace re-established the market at that figure, after a spell in which \$17.75 was the usual selling price. One of the sales was of 600 tons by a steel interest, the other being 1,000 tons by a merchant furnace interest. Foundry iron has sold so frequently at \$19 valley, although in small lots, that this may be considered the market, against a range of \$18.75@ \$19 formerly quoted. Bessemer remains at \$19.50 valley in small lots, with a possibility of shading in case of a large tonnage.

COKE

Connellsville coke, which stiffened somewhat at the close of last week, is easier this week, with spot prices the same as quoted one week or two weeks ago, \$3.25@ \$3.50 for furnace and \$4.25@ \$4.75 for foundry. There is no decrease in demand to account for the easier tone, which is obviously due to the distinct decrease in late in demand for coal, a decrease that must be considered in the light of the fact that Connellsville operators expected an increase, or a last minute rush, as April 1 was approached, on account of the prospective suspension at the union mines.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride.....lb.		\$0.40 - \$0.42
Acetone.....lb.	\$0.11 - \$0.12	.12 - .12
Acid, acetic, 28 per cent.....100 lbs.	2.50 - 2.60	2.65 - 3.00
Acetic, 56 per cent.....100 lbs.	5.00 - 5.25	5.30 - 5.50
Acetic, glacial, 99 1/2 per cent, carboys.....100 lbs.	9.00 - 9.50	9.75 - 10.00
Boric, crystals.....lb.	.11 - .11 1/2	.11 - .12
Boric, powder.....lb.	.11 - .11 1/2	.11 - .12
Citric.....lb.	.11 - .11 1/2	.11 - .12
Hydrochloric.....100 lb.	1.15 - 1.25	1.30 - 1.75
Hydrofluoric, 52 per cent.....lb.	.11 - .11 1/2	.11 - .12
Lactic, 44 per cent tech.....lb.	.09 - .10	.10 - .12
Lactic, 22 per cent tech.....lb.	.04 - .04 1/2	.04 - .05
Molybdic, a.p.....lb.	3.00 - 3.25	3.30 - 3.75
Muriatic, 20 deg. (see hydrochloric).....lb.		
Nitric, 40 deg.....lb.	.06 - .06 1/2	.06 - .07
Nitric, 42 deg.....lb.	.06 - .07	.07 - .07 1/2
Oxalic, crystals.....lb.	.12 - .12 1/2	.13 - .14
Phosphoric, 50 per cent solution.....lb.	.08 - .08 1/2	.08 - .09
Picric.....lb.	.20 - .25	.27 - .35
Pyrogallol, resublimed.....lb.		1.65 - 1.75
Sulphuric, 60 deg., tank cars.....ton	10.00 - 11.00	
Sulphuric, 60 deg., drums.....ton	12.00 - 14.00	
Sulphuric, 66 deg., tank cars.....ton	16.00 - 16.50	
Sulphuric, 66 deg., drums.....ton	20.00 - 20.50	21.00 - 22.00
Sulphuric, 66 deg., carboys.....ton		
Sulphuric, fuming, 20 per cent (oleum) tank cars.....ton	19.50 - 20.00	
Sulphuric, fuming, 20 per cent (oleum) drums.....ton	22.00 - 22.50	23.00 - 24.00
Sulphuric, fuming, 20 per cent (oleum) carboys.....ton	31.00 - 32.00	33.00 - 34.00
Tannic, U. S. P.....lb.		.60 - .75
Tannic (tech.).....lb.	.40 - .45	.46 - .50
Tartaric, imported crystals.....lb.		.26 - .28
Tartaric acid, imported, powdered.....lb.		.27 - .30
Tartaric acid, domestic.....lb.		.30 - .30
Tungstic, per lb. of WO.....lb.		1.00 - 1.10
Alcohol, ethyl.....gal.		4.75 - 5.50
Alcohol, methyl (see methanol)		
Alcohol, denatured, 188 proof No. 1 gal.		.32 - .34
Alcohol, denatured, 188 proof No. 5 gal.		.32 - .34
Alum, ammonia, lump.....lb.	.03 - .03 1/2	.04 - .04 1/2
Alum, potash, lump.....lb.	.03 - .03 1/2	.03 - .04
Alum, chrome, lump.....lb.	.07 - .08	.08 - .08 1/2
Aluminum sulphate, commercial.....100 lb.	1.65 - 1.85	1.90 - 2.40
Aluminum sulphate, iron free.....lb.	.02 - .02 1/2	.03 - .03 1/2
Aqua ammonia, 26 deg. drums (750 lb.) lb.	.07 - .07 1/2	.08 - .08 1/2
Ammonia, anhydrous, cyl. (100-150 lb.) lb.	.30 - .30 1/2	.31 - .33
Ammonium carbonate, powder.....lb.	.07 - .07 1/2	.08 - .09
Ammonium nitrate.....lb.	.06 - .07	.07 - .07 1/2
Amylacetate tech.....gal.		2.00 - 2.40
Arsenic, white, powdered.....lb.	.07 - .07 1/2	.07 - .08
Arsenic, red, powdered.....lb.	.12 - .12 1/2	.12 - .13
Barium chloride.....ton	66.00 - 66.50	66.75 - 70.00
Barium dioxide (peroxide).....lb.	.20 - .21	.21 - .22
Barium nitrate.....lb.	.06 - .07	.07 - .08 1/2
Barium sulphate (precip.) (blanc fixe) lb.	.03 - .04	.04 - .04 1/2
Blanc fixe, dry.....lb.	.04 - .04 1/2	
Blanc fixe, pulp.....ton	45.00 - 55.00	
Bleaching powder.....100 lb.	1.75 - 2.00	2.05 - 3.00
Blue vitriol (see copper sulphate).....lb.	.05 - .05 1/2	.06 - .06 1/2
Borax.....lb.		
Brimstone (see sulphur, roll).....lb.	.27 - .28	.28 - .35
Bromine.....100 lbs.	1.75 - 2.00	
Calcium acetate.....100 lbs.	.04 - .04 1/2	.05 - .05 1/2
Calcium carbide.....ton	24.00 - 24.50	24.75 - 27.00
Calcium chloride, fused, lump.....lb.	.01 - .02	.02 - .02 1/2
Calcium chloride, granulated.....lb.		1.40 - 1.50
Calcium peroxide.....lb.		.15 - .16
Calcium phosphate, tribasic.....lb.		.91 - .93
Camphor.....lb.	.06 - .06 1/2	.06 - .07 1/2
Carbon bisulphide.....lb.	.09 - .10	.10 - .12
Carbon tetrachloride, drums.....lb.		.60 - .75
Carbonyl chloride (phosgene).....lb.		
Caustic potash (see potassium hydroxide)		
Caustic soda (see sodium hydroxide)		
Chalk, precip.—domestic, light.....lb.	.04 - .04 1/2	.04 - .05
Chalk, precip.—domestic, heavy.....lb.	.03 - .03 1/2	
Chalk, precip.—imported, light.....lb.	.04 - .05	
Chlorine, gas, liquid-cylinders (100 lb.) lb.	.06 - .06 1/2	.06 - .07
Chloroform.....lb.		.37 - .40
Cobalt oxide.....lb.		2.00 - 2.10
Copperas.....ton	15.00 - 16.00	16.50 - 30.00
Copper carbonate, green precipitate.....lb.	.19 - .20	.20 - .21
Copper cyanide.....lb.	.58 - .60	
Copper sulphate, crystals.....100 lb.	5.55 - 5.65	5.70 - 6.25
Cream of tartar.....lb.		.23 - .25
Epsom salt (see magnesium sulphate).....lb.		.60 - .65
Ethyl acetate com. 85%.....gal.		.93 - 1.00
Ethyl acetate, pure (acetic ether, 98% to 100%).....gal.	.09 - .09 1/2	.09 - .10
Formaldehyde, 40 per cent.....lb.	16.00 - 17.00	
Fullers earth, f.o.b. mines.....net ton	30.00 - 32.00	
Fullers earth—imported powdered—net ton		2.50 - 3.00
Fusel oil, ref.....gal.		1.40 - 1.75
Fusel oil, crude.....gal.		
Glauber's salt (see sodium sulphate).....lb.		.16 - .17
Glycerine, a. p. drums extra.....lb.		4.05 - 4.15
Iodine, resublimed.....lb.		.12 - .18
Iron oxide, red.....lb.		.09 - .11
Lead acetate, powd.....lb.	.15 - .15 1/2	.15 - .16 1/2
Lead nitrate.....lb.	.07 - .07 1/2	.08 - .08 1/2
Litharge.....lb.	.06 - .06 1/2	.06 - .08
Magnesium carbonate, technical.....lb.	2.60 - 2.65	2.70 - 3.00
Magnesium sulphate, U. S. P.....100 lb.		1.00 - 1.80
Magnesium sulphate, technical.....100 lb.		.57 - .58
Methanol, 95%.....gal.		.59 - .60
Methanol, 97%.....gal.		.11 - .11 1/2
Nickel salt, double.....lb.		.11 - .11 1/2
Nickel salt, single.....lb.		.45 - .46
Phosgene (see carbonyl chloride).....lb.		.47 - .50
Phosphorus, red.....lb.		.30 - .35
Phosphorus, yellow.....lb.		

	Carlots	Less Carlots
Potassium bichromate.....lb.	.10 - .10 1/2	.10 - .10 1/2
Potassium bromide, granular.....lb.	.18 - .24	.18 - .24
Potassium carbonate, U. S. P.....lb.	.12 - .12 1/2	.13 - .16
Potassium carbonate, 80-85%.....lb.	.04 - .04 1/2	.04 - .05 1/2
Potassium chlorate, crystals.....lb.	.05 - .06	.06 - .08
Potassium cyanide.....lb.		.42 - .45
Potassium hydroxide (caustic potash) 100 lb.	5.75 - 5.85	5.90 - 6.50
Potassium iodide.....lb.		3.10 - 3.15
Potassium nitrate.....lb.	.07 - .07 1/2	.08 - .09
Potassium permanganate.....lb.	.16 - .17	.17 - .22
Potassium prussiate, red.....lb.	nominal	nominal
Potassium prussiate, yellow.....lb.	.25 - .26	.26 - .26 1/2
Rochelle salts (see sodium potas tartrate)		
Salammoniac, white, granular.....lb.	.07 - .07 1/2	.07 - .08
Salammoniac, gray, granular.....lb.	.07 - .07 1/2	.07 - .08
Salsoda.....100 lb.	1.60 - 1.70	1.75 - 2.00
Salt cake (bulk).....ton	17.00 - 20.00	
Soda ash, light.....100 lb.	1.80 - 2.00	2.05 - 2.60
Soda ash, dense.....100 lb.	1.85 - 1.95	2.00 - 2.50
Sodium acetate.....lb.	.04 - .04 1/2	.04 - .05
Sodium bicarbonate.....100 lb.	1.90 - 2.00	2.05 - 2.40
Sodium bichromate.....lb.	.07 - .08	.08 - .08 1/2
Sodium bisulphate (nitre cake).....ton	4.50 - 4.60	4.65 - 5.50
Sodium bisulphate powdered, U.S.P.....lb.	.04 - .04 1/2	.04 - .05 1/2
Sodium chloride.....lb.	.06 - .07	.07 - .07 1/2
Sodium chloride.....long ton	12.00 - 13.00	.26 - .27 1/2
Sodium cyanide.....lb.	.22 - .26	.26 - .27 1/2
Sodium fluoride.....lb.	.10 - .10 1/2	.10 - .11
Sodium hydroxide (caustic soda).....100 lb.	3.70 - 3.75	3.80 - 4.30
Sodium hypsulphite.....lb.	.03 - .03 1/2	.03 - .04
Sodium nitrite.....lb.	.09 - .09 1/2	.09 - .10
Sodium peroxide, powdered.....lb.	.28 - .30	.31 - .35
Sodium phosphate, dibasic.....lb.	.03 - .04	.04 - .04 1/2
Sodium potassium tartrate (Rochelle salts) lb.		.18 - .21
Sodium prussiate, yellow.....lb.	.17 - .18	.18 - .18 1/2
Sodium silicate, solution (40 deg.).....100 lb.	.85 - 1.00	1.05 - 1.15
Sodium silicate, solution (60 deg.).....100 lb.	2.50 - 2.60	2.65 - 3.00
Sodium sulphate, crystals (Glauber's salt) 100 lbs.	.95 - 1.10	1.15 - 1.50
Sodium sulphide, f. sed. 60-62 per cent (conc.) lb.	.04 - .04 1/2	.04 - .05
Sodium sulphite, crystals.....lb.	.03 - .03 1/2	.03 - .04 1/2
Strontium nitrate, powdered.....lb.	.10 - .11	.11 - .15
Sulphur chloride, yellow.....ton	.04 - .05	.05 - .06
Sulphur, crude.....ton	18.00 - 20.00	
Sulphur dioxide, liquid, cylinders extra.....lb.	.08 - .08 1/2	.09 - .10
Sulphur (sublimed), flour.....100 lb.		2.25 - 3.10
Sulphur, roll (brimstone).....100 lb.		2.00 - 2.75
Talc—imported.....ton	30.00 - 40.00	
Talc—domestic powdered.....ton	18.00 - 25.00	
Tin bichloride.....lb.	.09 - .09 1/2	.09 - .10
Tin oxide.....lb.		.37 - .38
Zinc carbonate.....lb.	.14 - .14 1/2	.14 - .15 1/2
Zinc chloride, gran.....lb.	.06 - .06 1/2	.06 - .07
Zinc cyanide.....lb.	.42 - .44	.45 - .47
Zinc oxide, XX.....lb.	.07 - .08	.08 - .08 1/2
Zinc sulphate.....100 lb.	2.75 - 3.00	3.05 - 3.30

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude.....lb.	\$1.00 - \$1.05
Alpha-naphthol, refined.....lb.	1.10 - 1.15
Alpha-naphthylamine.....lb.	.30 - .31
Aniline oil, drums extra.....lb.	.16 - .17
Aniline salts.....lb.	.24 - .26
Anthracene, 80% n drums (100 lb.).....lb.	.75 - 1.00
Benzaldehyde U.S.P.....lb.	1.25 - 1.30
Benzidine, base.....lb.	.85 - .95
Benzidine sulphate.....lb.	.75 - .85
Benzoic acid, U.S.P.....lb.	.60 - .65
Benzoate of soda, U.S.P.....lb.	.55 - .57
Benzene, pure, water-white, in drums (100 gal.).....gal.	.29 - .35
Benzene, 90%, in drums (100 gal.).....gal.	.27 - .32
Benzyl chloride, 95-97% refined.....lb.	.25 - .27
Benzyl chloride, tech.....lb.	.20 - .23
Beta-naphthol benzoate.....lb.	3.75 - 4.00
Beta-naphthol, sublimed.....lb.	.60 - .65
Beta-naphthol, tech.....lb.	.27 - .30
Beta-naphthylamine, sublimed.....lb.	1.30 - 1.60
Cresol, U. S. P., in drums (100 lb.).....lb.	.12 - .15
Ortho-cresol, in drums (100 lb.).....lb.	.16 - .18
Cresylic acid, 97-99%, straw color, in drums.....gal.	.50 - .52
Cresylic acid, 95-97%, dark, in drums.....gal.	.45 - .47
Dichlorobenzene.....lb.	.06 - .09
Diethylaniline.....lb.	1.10 - 1.15
Dimethylaniline.....lb.	.38 - .40
Dinitrobenzene.....lb.	.22 - .25
Dinitrochlorobenzene.....lb.	.23 - .25
Dinitronaphthalene.....lb.	.32 - .35
Dinitrophenol.....lb.	.35 - .38
Dinitrotoluene.....lb.	.22 - .24
Dip oil, 25%, car lots, in drums.....gal.	.24 - .26
Diphenylamine.....lb.	.59 - .70
H-acid.....lb.	.85 - 1.00
Meta-phenylenediamine.....lb.	.90 - 1.00
Monochlorobenzene.....lb.	.14 - .15
Monochloroaniline.....lb.	1.20 - 1.25
Naphthalene crushed, in bbls.....lb.	.06 - .06 1/2
Naphthalene, flake.....lb.	.06 - .07
Naphthalene, balls.....lb.	.08 - .08 1/2
Naphthionic acid, crude.....lb.	.65 - .70
Nitrobenzene.....lb.	.10 - .12
Nitro-naphthalene.....lb.	.30 - .35
Nitro-toluene.....lb.	.15 - .17 1/2
Ortho-amidophenol.....lb.	2.75 - 2.80
Ortho-dichlorobenzene.....lb.	.15 - .20
Ortho-nitro-phenol.....lb.	.75 - .80
Ortho-nitro-toluene.....lb.	.15 - .20
Ortho-toluidine.....lb.	.20 - .25
Para-amidophenol, base.....lb.	1.25 - 1.30
Para-amidophenol, HCl.....lb.	1.30 - 1.35
Para-dichlorobenzene.....lb.	.15 - .18
Paranitroaniline.....lb.	.75 - .77
Para-nitrotoluene.....lb.	.70 - .75
Para-phenylenediamine.....lb.	1.50 - 1.55
Para-toluidine.....lb.	1.10 - 1.15
Phthalic anhydride.....lb.	.35 - .38

Phenol, U. S. P., drums.....	lb.	.11	—	.15
Pyridine.....	gal.	1.75	—	2.75
Resorcinol, technical.....	lb.	1.25	—	1.30
Resorcinol, pure.....	lb.	1.60	—	1.95
Salicylic acid, tech., in bbls.....	lb.	.20	—	.21
Salicylic acid, U. S. P.....	lb.	.22	—	.23
Salol.....	lb.	.80	—	.82
Solvent naphtha, water-white, in drums, 100 gal.....	gal.	.25	—	.28
Solvent naphtha, crude, heavy, in drums, 100 gal.....	gal.	.12	—	.14
Sulphanilic acid, crude.....	lb.	.25	—	.27
Tolidine.....	lb.	1.20	—	1.30
Toluidine, mixed.....	lb.	.32	—	.38
Toluene, in tank cars.....	gal.	.25	—	.28
Toluene, in drums.....	gal.	.30	—	.35
Xylidines, drums, 100 gal.....	lb.	.40	—	.45
Xylene, pure, in drums.....	gal.	.40	—	.45
Xylene, pure, in tank cars.....	gal.	.45	—	.50
Xylene, commercial, in drums, 100 gal.....	gal.	.33	—	.35
Xylene, commercial, in tank cars.....	gal.	.30	—	....

Waxes

Prices based on original packages in large quantities.

Bayberry Wax.....	lb.	\$0.20	—	\$0.21
Beeswax, refined, dark.....	lb.	.25	—	.28
Beeswax, refined, light.....	lb.	.30	—	.32
Beeswax, white pure.....	lb.	.35	—	.40
Candelilla, wax.....	lb.	.25	—	.26
Carnauba, No. 1.....	lb.	.45	—	.46
Carnauba No. 2, North Country.....	lb.	.25	—	.26
Carnauba, No. 3, North Country.....	lb.	.15	—	.16
Japan.....	lb.	.18	—	.18
Montan, crude.....	lb.	.04	—	.05
Paraffine waxes, crude match wax (white) 105-110 m.p.....	lb.	.04	—	.04
Paraffine waxes, crude, scale 124-126 m.p.....	lb.	.02	—	....
Paraffine waxes, refined, 118-120 m.p.....	lb.	.03	—	.03
Paraffine waxes, refined, 125 m.p.....	lb.	.03	—	.03
Paraffine waxes, refined, 128-130 m.p.....	lb.	.04	—	.04
Paraffine waxes, refined, 133-135 m.p.....	lb.	.04	—	.05
Paraffine waxes, refined, 135-137 m.p.....	lb.	.05	—	.05
Stearic acid, single pressed.....	lb.	.08	—	.09
Stearic acid, double pressed.....	lb.	.09	—	.09
Stearic acid, triple pressed.....	lb.	.10	—	.10

Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.....	280 lb.	\$5.15	—	5.20
Rosin E-I.....	280 lb.	5.25	—	5.30
Rosin K-N.....	280 lb.	5.90	—	6.65
Rosin W, G-W W.....	280 lb.	7.00	—	7.25
Wood rosin, bbl.....	280 lb.	6.25	—	....
Spirits of turpentine.....	gal.	.85	—	....
Wood turpentine, steam dist.....	gal.	.82	—	....
Wood turpentine, dest. dist.....	gal.	.68	—	.70
Pine tar pitch, bbl.....	200 lb.	....	—	6.00
Tar, kiln burned, bbl (500 lb.).....	bbl.	....	—	9.50
Retort tar, bbl.....	500 lb.	....	—	9.00
Rosin oil, first run.....	gal.	.36	—	....
Rosin oil, second run.....	gal.	.38	—	....
Rosin oil, third run.....	gal.	.46	—	....
Pine oil, steam dist., sp.gr. 0.930-0.940.....	gal.	\$1.90	—	....
Pine oil, pure, dest. dist.....	gal.	1.50	—	....
Pine tar oil, ref., sp.gr. 1.025-1.035.....	gal.	.46	—	....
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.....	gal.	....	—	.35
Pine tar oil, double ref., sp.gr. 0.965-0.990.....	gal.	....	—	.35
Pine tar, ref., thin, sp.gr. 1.080-1.060.....	gal.	....	—	.35
Turpentine, crude, sp. gr. 0.900-0.970.....	gal.	....	—	1.25
Hardwood oil, f.o.b. Mich., sp.gr. 0.960-0.990.....	gal.	....	—	.35
Pinewood creosote, ref.....	gal.	....	—	.52

Fertilizers

Ammonium sulphate, bulk and double bags.....	100 lb.	3.25	—	....
Blood, dried, f.o.b., N. Y.....	unit	4.00	—	....
Bone, 3 and 50, ground, raw.....	ton	30.00	—	32.00
Fish scrap, dom., dried, f.o.b. works.....	unit	2.90	—	3.00
Nitrate soda.....	100 lb.	2.85	—	2.95
Tankage, high grade, f.o.b. Chicago.....	unit	3.60	—	....
Phosphate rock, f.o.b. mines, Florida pebble, 68-72%.....	ton	3.50	—	3.75
Tennessee, 78-80%.....	ton	6.00	—	7.50
Potassium muriate, 80%.....	ton	34.00	—	35.00
Potassium sulphate.....	unit	1.00	—	....

Crude Rubber

Prices remain same as previous report.

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.....	lb.	\$0.10	—	\$0.10
Castor oil, AA, in bbls.....	lb.	.11	—	.12
China wood oil, in bbls.....	lb.	.14	—	.14
Coconut oil, Ceylon grade, in bbls.....	lb.	.09	—	.09
Coconut oil, Cochon grade, in bbls.....	lb.	.09	—	.10
Corn oil, crude, in bbls.....	lb.	.11	—	.11
Cottonseed oil, crude (f. o. b. mill).....	lb.	.10	—	.10
Cottonseed oil, summer yellow.....	lb.	.11	—	.12
Cottonseed oil, winter yellow.....	lb.	.13	—	.13
Linseed oil, raw, car lots (domestic).....	gal.	.81	—	.82
Linseed oil, raw, tank cars (domestic).....	gal.	.77	—	.78
Linseed oil, in 5-bbl lots (domestic).....	gal.	.84	—	.85

Olive oil, denatured.....	gal.	1.15	—	1.20
Palm, Lagos.....	lb.	.08	—	.08
Palm, Niger.....	lb.	.06	—	.06
Peanut oil, crude, tank cars (f.o.b. mill).....	lb.	.10	—	.10
Peanut oil, refined, in bbls.....	lb.	.13	—	.13
Rapeseed oil, refined in bbls.....	gal.	.85	—	.86
Rapeseed oil, blown, in bbls.....	gal.	.87	—	.88
Soya bean oil (Manchurian), in bbls. N. Y.....	lb.	.11	—	....
Soya bean oil, tank cars, f.o.b., Pacific coast.....	lb.	.09	—	....

FISH

Light pressed menhaden.....	gal.	\$0.54	—	....
Yellow bleached menhaden.....	gal.	.57	—	....
White bleached menhaden.....	gal.	.56	—	....
Blown menhaden.....	gal.	.61	—	....

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Shellac, orange fine.....	lb.	.86	—	.87
Shellac, orange superfine.....	lb.	.88	—	.89
Shellac, A. C. garnet.....	lb.	.70	—	.71
Shellac, T. N.....	lb.	.63	—	.64

All other prices remain unchanged.

Refractories

Prices remain quotably unchanged.

Ferro-Alloys

Ferromanganese, 76-80% Mn, Domestic, gross ton \$62.50.

All other prices remain the same as previous report.

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al content.....	net ton	\$6.00	—	\$12.00
Chrome ore, Calif. concentrates, 50% min. Cr ₂ O ₃	ton	19.00	—	20.00
Chrome ore, 50% Cr ₂ O ₃ , f.o.b. Atlantic seaboard.....	ton	19.00	—	20.00
Coke, foundry, f.o.b. ovens.....	net ton	4.25	—	4.75
Coke, furnace, f.o.b. ovens.....	net ton	3.25	—	3.50
Fluorspar, gravel, f.o.b. mines, New Mexico.....	net ton	12.00	—	....
Fluorspar, standard, domestic washed gravel.....	net ton	20.00	—	22.00
Kentucky and Illinois mines.....	lb.	.01	—	.01
Ilmenite, 52% TiO ₂ per lb. ore.....	unit	.24	—	.25
Manganese ore, 50% Mn, c.i.f. Atlantic seaport.....	net ton	55.00	—	60.00
Manganese ore, chemical (MnO ₂).....	lb.	.40	—	.43
Molybdenite, 85% MoS ₂ per lb. of MoS ₂ , N. Y.....	unit	27.00	—	....
Monazite, per unit of ThO ₂ , c.i.f., Atlantic seaport.....	unit	.12	—	.12
Pyrites, Spanish, fines, c.i.f., Atlantic seaport.....	unit	.13	—	.13
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport.....	unit	.11	—	.12
Pyrites, domestic, fines, f.o.b. mines, Ga.....	lb.	.12	—	....
Rutile, 95% TiO ₂ per lb. ore.....	unit	2.25	—	2.50
Tungsten, scheelite, 60% WO ₃ and over, per unit of WO ₃ (nominal).....	unit	2.50	—	2.75
Tungsten, wolframite, 60% WO ₃ and over, per unit of WO ₃ , N. Y. C.....	unit	1.25	—	1.75
Uranium ore (carnotite) per lb. of U ₃ O ₈	lb.	2.25	—	2.50
Uranium oxide, 96% per lb. contained U ₃ O ₈	lb.	12.00	—	14.00
Vanadium pentoxide, 99%.....	lb.	1.00	—	....
Vanadium ore, per lb. of V ₂ O ₅ contained.....	lb.	.04	—	.13
Zircon, washed, iron free, f.o.b. Pablo, Florida.....	lb.	....	—	....

Non-Ferrous Metals

New York Markets

Copper, electrolytic.....		Cents per Lb.
Aluminum, 98 to 99 per cent.....		12.75-13.00
Antimony, wholesale lots, Chinese and Japanese.....		19.00
Nickel, ordinary (ingot).....		4.25
Nickel, electrolytic.....		41.00
Nickel, electrolytic, resale.....		44.00
Monel metal, shot and blocks.....		32.00
Monel metal, ingots.....		35.00
Monel metal, sheet bars.....		38.00
Tin, 5-ton lots, Straits.....		40.00
Lead, New York, spot.....		29.125
Lead, E. St. Louis, spot.....		4.70
Zinc, spot, New York.....		4.40-4.45
Zinc, spot, E. St. Louis.....		5.15
		4.70

OTHER METALS

Silver (commercial).....	oz.	\$0.63
Cadmium.....	lb.	1.00-1.10
Bismuth (500 lb. lots).....	lb.	2.00@2.10
Cobalt.....	lb.	3.00@3.25
Magnesium.....	lb.	1.15
Platinum.....	oz.	85.00@90.00
Iridium.....	oz.	170.00@190.00
Palladium.....	oz.	55.00@60.00
Mercury.....	75 lb.	51.00

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by $\frac{1}{2}$ in. and larger, and plates $\frac{1}{2}$ in. and heavier, from jobbers' warehouses in the cities named:

	New York*	Chicago
Structural shapes.....	\$2.63	\$2.38
Soft steel bars.....	2.53	2.28
Soft steel bar shapes.....	2.53	2.28
Soft steel bands.....	3.13	2.88
Plates, $\frac{1}{2}$ to 1 in. thick.....	2.63	2.38

*Add 15¢ per 100 lb. for trucking to Jersey City and 10¢ for delivery in New York.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

BIRMINGHAM—The Birmingham Water Works Co. will install new filtration and purification equipment at its plant in connection with general improvements and extensions. The company is arranging for an increase in capital from \$2,529,700 to \$3,039,700, and more than one-half of the proceeds will be used for the work.

California

MOJAVE—The Jo Rand Smelting Co., Bakersfield, Cal., recently organized, is planning for the erection of a new smelting plant on site selected at Mojave. R. L. Gilmore, Bakersfield, is secretary and treasurer.

BOALINGA—The Council has called a special election, April 10, to vote bonds for the erection of a 100,000 cu ft. gas plant and holder for municipal service.

Delaware

WILMINGTON—The Martin Leather Co., 703 East 5th St., has filed plans for the erection of a 2-story addition to its tanning plant, with wings, 47 x 126 ft. and 36 x 48 ft.

Idaho

COEUR D'ALENE—Idaho Clays, Inc., recently organized, is perfecting plans for the erection of a new plant on site selected in the Hayden Lake section in the eastern district of the city. The plant will consist of a number of buildings for the manufacture of a general line of burned clay products, estimated to cost about \$500,000, including machinery. The works will include a power plant for operation.

Indiana

VALPARAISO—Frank W. Lesch, superintendent at the plant of the Pitkin & Brooks Glass Co., has acquired the plant and property of the company and will take possession on May 1. It is proposed to discontinue operations at the local factory and remove the machinery to another location, where increased manufacture will be provided. The local Chamber of Commerce is interested in the project.

Kentucky

LEACH—The Great Eastern Refining Co. is planning for the erection of a new oil refinery on local site to cost about \$250,000, including equipment. Plans will be drawn at an early date.

Maryland

BALTIMORE—The Patuxent Clay Products Co., 210 Equitable Trust Bldg., has selected a site at Patuxent, Md., for the erection of a new plant for the manufacture of a line of burned clay products. It will consist of a number of buildings, estimated to cost about \$100,000, including equipment. I. P. Mills is in charge.

BALTIMORE—The Colloidal Process Paint Co. has work in progress on a new local plant, to be used primarily for the processing of bitumens.

BALTIMORE—The Prudential Oil Co., Keyser Bldg., has acquired a tract of land adjoining its plant on 7th St., East Brooklyn, totaling about 6½ acres, to be used for extensions. The property was obtained for a consideration of \$22,000.

BALTIMORE—Gilpin, Langdon & Co., Inc., 300 West Lombard St., manufacturer of chemicals, drugs, etc., has broken ground for the erection of a 1-story plant, 65 x 211 ft., at Smallwood and Eagle Sts., estimated to cost about \$55,000. Frairie Bros. & Halpley, 19 Clay St., are the building contractors.

BALTIMORE—The Atlas Chemical Laboratories, Inc., 1717 Mosher St., recently organized with a capital of \$50,000, has plans

under way for the establishment of a local plant for the manufacture of chemical sanitation specialties. It is planned to commence operations at an early date. John E. Auld, Jr., is president, and John E. Auld, Sr., treasurer.

Massachusetts

EVERETT—A portion of the works of the Merrimac Chemical Co., located on the banks of the Mystic River, including three buildings, was destroyed by fire, March 7, with loss estimated at about \$20,000.

LEOMINSTER—The Atlantic Refining Co., Hospital Trust Bldg., Providence, R. I., will commence work at once on a new oil-distributing plant on North Main St., Leominster.

Michigan

DETROIT—The Detroit Sand Lime Brick Co., 507 Vinton Bldg., is completing plans for the erection of its proposed new plant on property recently acquired at River Rouge, Mich., to consist of a number of buildings. It is expected to call for bids at an early date.

BAY CITY—The local Chamber of Commerce has announced that the Andrews Steel Co., Newport, Ky., affiliated with the Kentucky Rolling Mills Co., of the same place, has taken an option on Bay City property, totaling about 150 acres, to be used as a site for the construction of a new blast furnace and steel works.

Missouri

ST. LOUIS—Fire, March 6, destroyed a portion of the plant of the Perfection Enamel Corp., 4528 Page Ave. The fire started in one of the drying ovens. An official estimate of loss has not been announced, but is said to be heavy.

Montana

GREAT FALLS—The American Zinc, Lead & Smelting Co., 120 Broadway, New York, N. Y., has acquired a controlling interest in the Silver Dike Mining Co., operating in the Great Falls district, for a consideration said to be \$125,000. The production is silver-lead-copper ores, and the new owner plans for extensive development and production.

New Jersey

TRENTON—The Star Porcelain Co., Muirheid Ave., has awarded a contract to the Karno-Smith Co., Trenton, for the construction of a new 1-story building at its plant, 71 x 101 ft.

NEWARK—The United Color & Pigment Co., Evergreen and McClellan Aves., has filed plans for the erection of an addition to its plant to cost about \$22,000. Work will be commenced at once.

BLOOMFIELD—A water-softening and filtration plant will be installed at the new local bleaching plant to be erected by the Clark Thread Co., 260 Ogden St., Newark, estimated to cost about \$200,000.

New York

HUDSON—The Hudson City Steel Co., 233 Broadway, New York, N. Y., has plans nearing completion for the erection of its proposed new plant at Hudson, to comprise six 1-story buildings, equipped for general steel products manufacture, estimated to cost close to \$800,000, with machinery. The work will be commenced at an early date. Dwight P. Robinson & Co., 125 East 46th St., New York, are engineers.

NEW YORK—The Rose Novelty Mirror Works has leased space in the building at 65-69 Varick St., for a new factory for the manufacture of mirrors and other kindred glass products.

TONAWANDA—The Beaver Board Co. has closed down its local works for extensive improvements and repairs. It is expected to have the plant ready for service in August. In the meantime, the company will concentrate on the manufacture of its composition wallboard products at its works at Thorold, Ont.; it is planned to install new equipment at this

plant, and to increase the working force by at least 100 men.

BUFFALO—The Water Bureau, George G. Andrews, Water Commissioner, City Hall, has plans in progress for the construction of a new filtration plant for the local waterworks, to be located at the Col. F. G. Wood Pumping Station. It is estimated to cost in excess of \$3,500,000, and the city has appropriated funds greater than this amount to carry out all details of installation. Clark D. Parsons, Fort Porter Ave., is engineer.

North Dakota

WILLISTON—F. J. Wilkinson, vice-president of the Williams County Bank, and associates are organizing a new company to construct and operate a local leather tannery. It will be 2-story and basement, 60 x 125 ft. and estimated to cost approximately \$30,000. George E. Ellinger, Havre, Mont., is architect.

Ohio

UTICA—The Licking Window Glass Co. is planning for the rebuilding of the portion of its plant, destroyed by fire, March 5, with loss estimated in excess of \$100,000, including equipment. Harry McCann is president.

CINCINNATI—The Ultra-Marine Co., Huntington, W. Va., will soon take bids for the erection of a new 1-, 2- and 3-story plant in the vicinity of Cincinnati, estimated to cost in excess of \$60,000. U. S. G. Anderson is president; E. C. Baugher, 539 22nd St., Huntington, is in charge of the project.

LIMA—The Lisbon Agricultural Lime Co., recently organized, has taken over the plant and business of the Lisbon Lime Co., and will operate the works in the future. Plans are under way for enlargements in the plant, with the installation of new equipment in different departments.

Oregon

PORTLAND—The Portland Vegetable Oil Mills Co., care of W. H. Curtis and L. R. Russe, engineers, Portland, will build a new local plant for the production of turpentine, rosin and kindred wood byproducts, to be extracted from Douglas fir pitch. Plans will be drawn at an early date. H. H. Ward is one of the heads of the company.

SCAPPOOSE—The Oregon Charcoal-Iron Co., A. W. Martin, head, has plans under way for the erection of a new plant, with furnace, etc., on local site. It will be used for pig-iron production and work will be placed under way at an early date. The complete plant is estimated to cost about \$200,000.

Pennsylvania

BRADFORD—The Interstate Glass Co., Bradford, has commenced work on extensions and improvements at its plant at Clarksburg, W. Va., estimated to cost about \$70,000. L. E. Stewart, Bradford, is engineer, H. J. Walters is president.

PITTSBURGH—Fire March 8 destroyed a portion of the plant of S. Struntz & Son, 702-716 Bingham St., manufacturers of soaps and kindred products, with loss estimated at about 40,000.

KANE—The Interstate Window Glass Co., Kane, is dismantling its plant at Smethport, Pa., including blowing machines, etc., and at a later date will install new and improved equipment to replace the machinery. Operations have been discontinued during the change.

Texas

NEW BOSTON—Fire Feb. 23 destroyed a portion of the plant of the New Boston Cotton Oil Co., with loss estimated at about \$75,000, including equipment. It is planned to rebuild.

THREE RIVERS—The Three Rivers Glass Co., recently organized, will establish a local plant for the manufacture of glass bottles and other glass products. H. L. Warrick is general manager.

West Virginia

CASS—The West Virginia Pulp & Paper Co., 200 Fifth Ave., New York, is said to be planning for the rebuilding of the portion of its pulp and wood plant at Cass, recently destroyed by fire with loss estimated at about \$200,000, including equipment.

Washington

SPOKANE—The Western Materials Co. is planning for the erection of a new magnesite mill on local site, to handle production from its quarry at Springdale, Wash. F. M. Handy is manager in charge.

Capital Increases, etc.

THE WHITE OIL CORP., 66 Broad St., New York, N. Y., has filed notice of increase in capital from \$100,000,000 to \$201,500,000.

THE HOME OIL & GAS CO., El Dorado, Ark., petroleum products, has filed notice of increase in capital to \$45,000.

THE THERASSE GLASS CORP., Marion, Ind., has filed notice of increase in capital from \$15,000 to \$50,000.

THE ROLLER OIL & REFINING CO., recently organized under Delaware laws, has filed notice of intention to operate at Mexia, Tex., with capital of \$3,000,000. H. C. Roller, Mexia, represents the company.

THE PURE OIL CO., 74 Broadway, New York, N. Y., is arranging for a new stock issue to total \$14,000,000, for general operations, financing, etc.

Jesse W. Ehrlich, receiver for the **WORLD RUBBER PRODUCTS CO., INC.**, 518 West 58th St., New York, N. Y., is arranging for the sale of the property of the company.

THE VIRGINIA ALDERENE CORP., 1511 Walnut St., Philadelphia, Pa., manufacturer of soapstone products, has disposed of a bond issue of \$750,000, the proceeds to be used for general operations and financing, including the recently acquired property of the Soapstone Products Co.

H. W. Holland has been appointed receiver for the **EL DORADO PETROLEUM CO.**, El Dorado, Ark. The company's liabilities are stated at \$720,000, and assets \$348,000.

THE STANDARD CHEMICAL WORKS, Reading, Pa., with branch plant at Wormisdorf, Pa., has arranged for an increase in capital from \$200,000 to \$500,000.

Elliot Frederick has been appointed ancillary receiver for the **ENGLE PAINT & VARNISH CO.**, Pittsburgh, Pa.

THE NATIONAL ENAMELING & STAMPING CO., 411 Fifth Ave., New York, N. Y., is considering a new note issue of \$15,000,000, for financing and general operations.

New Companies

THE IRONITE CORPORATION OF AMERICA, New York, N. Y., has been incorporated with a capital of \$300,000, to manufacture powders for welding service and kindred products. The incorporators are H. H. Drysen, H. Schulze and O. Hackeman. The company is represented by Charles A. Oberwager, 233 Broadway, New York.

THE ATLANTIC TAR & CHEMICAL WORKS, LTD., Jersey City, N. J., has been incorporated with a capital of \$300,000, to manufacture chemicals and chemical byproducts. The company is represented by the Corporation Trust Co., 15 Exchange Pl., Jersey City.

THE WHALEBACK OIL CO., Oklahoma City, Okla., has been incorporated with a capital of \$50,000, to manufacture petroleum products. G. D. Samuel, 606 Francis Ave., Houston, Tex., is president.

THE HERMO CO., 542 East 63rd St., Chicago, Ill., has been incorporated with a capital of \$300,000, to manufacture oils, colors, etc. The incorporators are Ernest A. Hoerich, Frederick W. Modersohn and Lowell F. Booton.

THE INDUSTRIAL LABORATORIES, INC., 640 Chestnut St., Grand Rapids, Mich., has been chartered under state laws to operate a chemical testing laboratory and research business. The incorporators are Elmer F. and Bert A. Way, and Walter K. Schmidt.

THE FRISKOPF COLOR & CHEMICAL CORP., New York, N. Y., has been incorporated with a capital of \$5,000, to manufacture chemicals, colors and affiliated products. The incorporators are A. and W. Friskopf. The company is represented by J. C. Wechsler, 261 Broadway.

THE BERTSMITH CHEMICAL CO., INC., Boston, Mass., has been incorporated with a capital of \$100,000, to manufacture chemicals and chemical byproducts. Thomas H. Smith, Dorchester, Mass., is president and treasurer.

THE O'NEAL LIME WORKS, INC., Wilmington, Del., has been incorporated under state laws with capital of \$2,000,000, to manufacture lime and affiliated products. The company is represented by the Corporation Service Co., Wilmington.

THE VERM-O-SPRAY PRODUCTS, INC., West Haven, Conn., has been incorporated with a capital of \$50,000, to manufacture insecticides, chemical products, etc. The incorporators are Charles Vincent, A. G. Sargent and Maurice Sulzbach, 78 East Ave., West Haven.

THE DIAMOND CANDLE CO., Brooklyn, N. Y., has been incorporated with a capital of \$40,000, to manufacture candles, wax

products and affiliated specialties. The incorporators are C. and G. F. Schisano, and H. T. Rosenfeld. The company is represented by Samuel Stark, 280 Broadway, New York.

THE MECHLING BROTHERS CHEMICAL CO., Camden, N. J., has been incorporated with a capital of \$1,000,000, to manufacture chemicals and chemical byproducts. The incorporators are William H., Edward A. and Benjamin S. Mechling, Line St. and Cooper's Creek, Camden.

THE C. H. WOLFELT CO., New York, N. Y., has been incorporated with a capital of \$400,000, under Delaware laws, to manufacture leather and rubber products. The incorporators are C. Irving Brown, James J. Watson and Tracy S. Buckingham, New York. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington, Del.

THE ROSMIL FIBRE CO., Boston, Mass., has been incorporated with 1,000 shares of stock, no par value, to manufacture fiber products. William R. Rogers is president; and M. F. McGrath, 293 Washington St., Boston, treasurer.

THE SUNSET TILE CO., 947 Elden Ave., Los Angeles, Cal., has filed notice of organization to manufacture ceramic tile products. The company is headed by G. S. Sinclair and C. S. Wallace.

MCCALVIN & CO., Jacksonville, Fla., has been incorporated with a capital of \$10,000, to manufacture soaps and kindred products. W. W. Parker is president and treasurer; and S. A. Logan, secretary, both of Jacksonville.

THE AMERICAN B. F. R. MFG. CO., 848 Noble St., Chicago, Ill., has been incorporated with a capital of \$15,000, to manufacture leather products. The incorporators are Isaac F. Potter, Peter P. Reisenhus and Baldwin S. Benton.

THE FLUID CHEMICAL CO., 149 High St., Newark, N. J., has filed notice of organization to manufacture washing fluids and other kindred chemical products. The company is headed by Frank Salvato.

THE ENDYNE CHEMICAL CO., Wilkesburg, Pa., has been incorporated under Delaware laws with capital of \$100,000, to manufacture chemicals and chemical byproducts. The incorporators are H. G. Hurney, Pittsburgh, Pa.; George L. and B. B. Ayres, Wilkesburg. The company is represented by the Capital Trust Co. of Delaware, Dover, Del.

THE LARKUM-WALD CO., Mt. Vernon, N. Y., has been incorporated with a capital of \$5,000, to manufacture chemicals and chemical byproducts. The incorporators are E. S. and I. C. Larkum, and M. Wald. The company is represented by H. D. Lent, Mt. Vernon.

THE PADUCAH CLAY CO., Paducah, Ky., has been incorporated with a capital of \$25,000, to manufacture clay products of various kinds. The incorporators are James S. Escott, E. I. Milburn and Elmer C. Ries, all of Paducah.

THE R. J. SPROUT LEATHER CO., INC., Boston, Mass., has been incorporated with a capital of \$5,000, to manufacture leather products. Robert J. Sprout, Everett, Mass., is president and treasurer.

THE KE-TOY MFG. CO., Brooklyn, N. Y., has been incorporated with a capital of \$10,000, to manufacture soaps and kindred products. The incorporators are R. L. Gordon and J. Margolis. The company is represented by Benjamin Marvin, 386 Fulton St., Jamaica, L. I.

THE REITER OIL CORP., Wilmington, Del., has been incorporated under state laws with a capital of \$1,000,000, to manufacture petroleum products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

THE SILVER REDUCTION CO., 2426 Clybourn Ave., Chicago, Ill., has been incorporated with a capital of \$50,000, to manufacture chemical solutions, metal reduction products, etc. The incorporators are Charles E. Johnson, Emerson B. Stoddard and Ralph E. Rich.

THE FLORIDA NOLENE PAINT CO., Lemon City, Fla., has been incorporated with a capital of \$25,000, to manufacture paints, varnishes, etc. I. B. Padgett is president; and W. D. Many, vice-president, both of Lemon City.

THE PALMER PRESSED BRICK WORKS, INC., Palmer, Ellis County, Tex., has been incorporated with a capital of \$21,000, to manufacture bricks and other burned clay products. The incorporators are J. R. Beck, Y. Barron and L. B. Griffith, all of Palmer.

H. P. DANIELSON, INC., 300 West Lake St., Chicago, Ill., has been incorporated with a capital of \$25,000, to manufacture leather products. The incorporators are Leo P. Wall, H. P. Danielson and Harold M. Pine.

THE GRUBER VARNISH CORP., New York, N. Y., has been incorporated with a capital of \$500,000, to manufacture paints, varnishes, etc. The incorporators are L. H. and F. R. Gruber, and L. Estander. The company is represented by Henry Hoelljes, 95 Madison Ave.

THE CONTINENTAL COLOR & CHEMICAL CO., Boston, Mass., has filed notice of organization to manufacture chemicals, colors, etc. The company is headed by Tracy L. Evans, 34 Merchants Row, Boston.

THE JOHN B. HEDIAN CO., 809 Hillen St., Baltimore, Md., has been incorporated with a capital of \$20,000, to manufacture salt products and affiliated specialties. The incorporators are John B. Hedian and Charles B. Hoffman.

THE COOPER CO., Elwood, Ind., has been incorporated with a capital of \$50,000, to manufacture steel and other metal castings. The incorporators are Clayton C. Cooper and William T. McNamara, both of Elwood.

THE PENINSULAR PHOSPHATE CORP., Wilmington, Del., has been incorporated under state laws with a capital of \$1,500,000, to operate phosphate properties, manufacture fertilizers, etc. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

F. HOUT & CO., New York, have been incorporated with a capital of \$5,000, to manufacture soaps and kindred products. The incorporators are R. P. Bramley and A. Henderson. The company is represented by H. A. Richards, 56 Pine St., New York.

Coming Meetings and Events

AMERICAN CHEMICAL SOCIETY will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Baltimore, April 27, 28 and 29, 1922. Headquarters will be at the Emerson Hotel.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its next convention and exhibit at Rochester, N. Y., during the week of June 5, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its summer meeting at Niagara Falls, June 19 to 22. Headquarters will be at the Clifton Hotel.

AMERICAN LEATHER CHEMISTS ASSOCIATION will hold its nineteenth annual meeting at Bigwin Inn, Bigwin Island, in the Lake of Bays district, Ontario, Canada, on June 21, 22 and 23.

AMERICAN SOCIETY FOR STEEL TREATING will hold a sectional meeting at the Bureau of Mines auditorium, Pittsburgh, Pa., on May 25 and 26. The International Steel Exposition and Convention of the society will be held in the General Motors Bldg., Detroit, Mich., Oct. 2 to 7.

AMERICAN SOCIETY FOR TESTING MATERIALS will hold its twenty-fifth annual meeting June 26 to July 1, at Atlantic City, N. J. Headquarters will be at the Chalfonte-Haddon Hall Hotel.

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY will hold a meeting at Lyons, France, June 27 to 30.

IRON AND STEEL INSTITUTE (British) will hold its annual meeting on May 4 and 5 at the House of the Institution of Civil Engineers, Great George St., S. W., 1, London.

NATIONAL ASSOCIATION OF PURCHASING AGENTS EXPOSITION (the "Informashow") will be held in connection with the seventh annual convention of the association at Exposition Park, Rochester, N. Y., May 15 to 22.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at Stettens Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

STAMFORD CHEMICAL SOCIETY, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists Club, New York: March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 13—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.